Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Air Force										DATE: February 2012	
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 2011**	**FY 2012**	**FY 2013 Base**	**FY 2013 OCO**	**FY 2013 Total**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**Cost To Complete**	**Total Cost**
Total Program Element	336.021	364.328	361.787	-	361.787	374.267	388.204	395.784	399.208	Continuing	Continuing
612301: *Physics*	47.953	-	-	-	-	-	-	-	-	Continuing	Continuing
612302: *Solid Mechanics and Structures*	19.649	-	-	-	-	-	-	-	-	Continuing	Continuing
612303: *Chemistry*	40.086	-	-	-	-	-	-	-	-	Continuing	Continuing
612304: *Mathematical and Computer Sciences*	35.945	-	-	-	-	-	-	-	-	Continuing	Continuing
612305: *Electronics*	42.865	-	-	-	-	-	-	-	-	Continuing	Continuing
612306: *Materials*	30.681	-	-	-	-	-	-	-	-	Continuing	Continuing
612307: *Fluid Mechanics*	25.579	-	-	-	-	-	-	-	-	Continuing	Continuing
612308: *Propulsion*	33.329	-	-	-	-	-	-	-	-	Continuing	Continuing
612311: *Information Sciences*	50.657	-	-	-	-	-	-	-	-	Continuing	Continuing
613001: *Physics and Electronics*	-	110.120	112.422	-	112.422	116.344	120.753	123.101	124.107	Continuing	Continuing
613002: *Aerospace, Chemical and Material Sciences*	-	139.475	108.982	-	108.982	112.743	116.983	119.243	120.216	Continuing	Continuing
613003: *Mathematics, Information and Life Sciences*	-	104.313	119.236	-	119.236	123.395	128.074	130.565	131.630	Continuing	Continuing
613004: *Education and Outreach*	-	10.420	21.147	-	21.147	21.785	22.394	22.875	23.255	Continuing	Continuing
614113: *External Research Programs Interface*	9.277	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, nine legacy Projects 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308 and 2311 were consolidated into three new Projects 3001, 3002, 3003 to more appropriately describe and align the changing focus of the scientific disciplines within the overall Basic Research Program. Also in FY 2012, External Research Programs - Project 4113 was renamed Education and Outreach- Project 3004 to more appropriately describe its mission.

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. All research areas are subject to long-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Air Force	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*

range planning and technical review by both Air Force and tri-Service scientific planning groups. Efforts in this program have been coordinated through the Reliance 21 process to harmonize efforts and eliminate duplication. This program is in Budget Activity 1, Basic Research, because it funds scientific study and experimentation.

B. Program Change Summary ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	350.978	364.328	379.046	-	379.046
Current President's Budget	336.021	364.328	361.787	-	361.787
Total Adjustments	-14.957	-	-17.259	-	-17.259
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-8.494	-			
• SBIR/STTR Transfer	-4.397	-			
• Other Adjustments	-2.066	-	-17.259	-	-17.259

Change Summary Explanation

FY11: Other Adjustments include: -2.066 (Congressional General Reductions)

Decrease in FY 2013 due to higher Department of Defense priorities.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force			DATE: February 2012
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*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612301: *Physics*	47.953	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3001 in this Program Element to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1. ***Description:*** Investigate regulated, broad-spectrum, variable-energy lasers, laser arrays, and novel bright incoherent light sources. ***FY 2011 Accomplishments:*** Extended studies on infrared semiconductor diode lasers to increase available power, efficiency, and wavelength range, at various temperatures. Studied 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 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	11.026	-	-	-	-
Title: Major Thrust 2.	14.240	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Description: Explore high-energy, electro-energetic device concepts and manipulation of atomic and molecular properties, atomic collision processes. ***FY 2011 Accomplishments:*** Continued to explore frequency comb techniques and ultracold atoms and molecules for precision measurement applications. Explored 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. Continued 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. Continued innovations in 3-D modeling of high power microwave (HPM) sources with emphasis on speeding execution times. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 3. ***Description:*** Advance technologies for space sensors, imaging, identification and tracking methods, and effective space situational awareness. ***FY 2011 Accomplishments:*** Continued to develop new sensing modalities that reduce limits on optical resolution and precision tracking of space objects. Investigated new methods of uniquely identifying unresolved space objects and incorporated this investigation in the identification of uncorrelated space objects. Continued study of the physics of signatures in the scattering and reflection of light during active imaging. Expanded research into fundamental processes and energy sources affecting satellite drag leading to improved understanding of precursors to atmospheric density variations. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:***	6.010	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 4. ***Description:*** Research space environment to improve solar plasma theories and modeling in the areas of solar phenomena, space weather, magneto/ionosphere effects, and adaptive optics. ***FY 2011 Accomplishments:*** Investigated proxy indicators of ionospheric and atmospheric processes that could be sensed using inexpensive but effective techniques. Investigated methods to exploit grid-free calculations of plasma processes in the magnetosphere and ionosphere as well as in the solar atmosphere and solar wind. Continued the study of energy flow between solar and terrestrial environments. Continued to study plasma instabilities and plasma processes in the equatorial and polar ionospheres. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	6.271	-	-	-	-
Title: Major Thrust 5. ***Description:*** Research physical mathematics and applied analysis to develop accurate models of physical phenomena to enhance the fidelity of simulation. Conduct research in electromagnetics. ***FY 2011 Accomplishments:*** Increased 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. These sources included 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	10.406	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
are standard fully coherent laser beams. Continued support of circuit upset research with emphasis on digital circuits. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	47.953	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
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*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612302: *Solid Mechanics and Structures*	19.649	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3002 in this Program Element to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	9.413	-	-	-	-
Description: Explore the integration of advanced materials, nano-materials, and devices into turbine engines, air vehicles, space systems, and other weapon systems. ***FY 2011 Accomplishments:*** Expanded research in the area of multifunctional materials and microsystems for autonomic sensing and self-diagnosis of exogenous threats. Continued research in the area of multifunctional materials and microsystems for reconfigurable structures allowing shape change and property tuning. Continued 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 developed the fundamental knowledge required to design and manufacture multi-functional aerospace material systems and devices and to predict their performance and structural integrity. ***FY 2012 Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
N/A ***FY 2013 Base Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Analyze structural fatigue and mechanics, adaptive structures, and material properties to improve the design, robustness, and performance of air and space systems. ***FY 2011 Accomplishments:*** Continued to seek new and revolutionary flight structure concepts that will permit broader operational capabilities, a faster reconfigurable ability, and more affordable accelerated fabrication. Investigated new structures of novel materials developed under the advanced materials programs. Expanded the understanding of structural health monitoring sensors and techniques, and tested the developed new science under laboratory conditions. Enhanced the understanding of dynamic and mechanical behavior of flight structures under extreme environments such as intense vibration, nonlinear structural dynamics, unsteady aero-thermo-elastic effects, and directed energy effects to increase operational survivability and mission success. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A	10.236	-	-	-	-
Accomplishments/Planned Programs Subtotals	19.649	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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*

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 2013 Air Force			DATE: February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612303: *Chemistry*	40.086	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3002 in this Program Element to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

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; nanostructures; 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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	16.985	-	-	-	-
Description: Research and characterize molecular dynamics, reaction mechanics/interactions, and theoretical chemistry to model, predict, control, and exploit atomic and molecular energetics.					
FY 2011 Accomplishments: Studied a fundamental understanding of basic chemical and physical processes on the nanoscale. Developed methods that can describe material behavior from the atomic level through mesoscopic and macroscopic scales and simulated chemical processes to model bulk scale properties. Developed theoretical methods to predict energy and density of novel energetic materials. Explored methods to use catalysis to improve energy utilization and storage. Created new selective and sensitive sensors for detecting trace species. Performed experiments and simulations to understand chemical processes in space for situational awareness. Investigated processes needed to assess scalability of hybrid laser concepts.					
FY 2012 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Enhance fundamental understanding of polymer chemical structures, reactivity, molecular engineering, processing controls, and materials technologies. ***FY 2011 Accomplishments:*** Explored organic transistors with flexibility, mechanical robustness and higher performance or equivalent of a-Si transistors. Explored rewritable color 3-D hologram displays using photorefractive polymers. Assessed feasibility of controlling chirality of molecular structures to achieve negative index behavior in the optical or infrared range. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	13.010	-	-	-	-
Title: Major Thrust 3. ***Description:*** Characterize, model, and exploit the fundamental chemistry and physics that govern surface and interfacial degradation from completely frictionless to total deterioration. ***FY 2011 Accomplishments:*** Applied 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. Investigated fundamental chemistry and physics of surface wear driving towards	10.091	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
a comprehensive understanding of the role of the chemical environment. Developed real-time nano-tribological instrumentation capable of in-situ friction, adhesion, and wear experimentation. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	40.086	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
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: *Mathematical and Computer Sciences*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612304: *Mathematical and Computer Sciences*	35.945	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3003 in this Program Element to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	18.286	-	-	-	-
Description: Perform dynamics and control research to develop innovative techniques for design and analysis of complex control systems. ***FY 2011 Accomplishments:*** Further developed 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, remotely piloted aircraft (RPAs), and constellations of small satellites. Developed 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. Continued development of control methodologies to improve non-equilibrium behavior of complex, nonlinear systems. Advanced image processing and sensor technologies for use in cooperative teams of RPAs and smart munitions to include multiple target tracking, ownship and world state estimation. Continued development of mathematical control theoretic models that capture the robust, nonlinear, hybrid dynamics of microbiological systems. Further 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,					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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: *Mathematical and Computer Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
large-scale networks. Continued development of theory and algorithms for specification, design, verification, and validation of distributed embedded control systems. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Conduct research in optimization, as well as computational and discrete mathematics, to validate and further advance mathematical methods, algorithms, and modeling and simulation. ***FY 2011 Accomplishments:*** Continued 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 emphasized the increasing challenges in capturing the unsteady, dynamic, multi-physics, and multi-scale nature of the problems. Supported development and integration of novel optimization strategies with high order, time-accurate solutions for superior design of Air Force systems. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	17.659	-	-	-	-
Accomplishments/Planned Programs Subtotals	35.945	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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: *Mathematical and Computer Sciences*

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612305: *Electronics*	42.865	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3001 in this Program Element to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	10.438	-	-	-	-
Description: Investigate novel detector and electronic materials, device concepts, and circuit architecture and implementation schemes important to future military space platforms. ***FY 2011 Accomplishments:*** Continued investigating novel multi-modal electromagnetic spectra detection approaches and concepts utilizing increased understanding of phenomenological interactions between target/background radiation and novel nanomaterials, structures, and devices. Specific emphasis was 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 were studied, along with concepts for thin-film spectra-filter tuning. Continued emphasis was placed on physics controlling semiconductor hetero-interface band misalignments that critically control carrier transport properties. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:***					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Investigate quantum and optoelectronic materials/devices, memory, information processing, and nanoscience for wide-field spectral sensors and critical, high-speed communication. ***FY 2011 Accomplishments:*** Continued efforts to better determine the optimal implementation of multi-ferroic materials for a wide variety of technologically advanced applications for the warfighter. Continued to explore the suitability of spintronic device elements that can be integrated into high performance, ultra-miniature logic and control systems. Explored special semiconducting and electronic materials that enable all photonic signal processing and logic technology, and began to explore integration of these advanced technologies with radio frequency (RF) micro electro-mechanical systems concepts. Explored wide band gap semiconductors for high performance, high power RF applications with an in-depth understanding of device reliability issues. Continued research on special materials and nanostructures that will permit an expansion of device functionality beyond the current limits on silicon technology. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	16.416	-	-	-	-
Title: Major Thrust 3. ***Description:*** Exploit advances in nanotechnology to support multi-spectral detection technology, chip-scale optical networks, and compact power. ***FY 2011 Accomplishments:*** Pursued 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	7.777	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
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. Continued to exploit silicon-compatible components for photonics and take advantage of the mature processing and manufacturing expertise that silicon technology affords. Pursued smaller and more highly integrated optical subsystems for telecommunications applications and high speed processing. Explored thermoelectric applications of silicon and germanium based nanomembranes made into nanowires and nanoribbons plus nanowire photovoltaic devices. Enhanced solar-energy conversion through plasmon enhanced photovoltaic films, and investigated the feasibilities of nitride based and non-traditional material nanostructures for applications in photoelectrochemical cell technology, and thermoelectric device technology. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 4. ***Description:*** Investigate quantum electronic solids phenomena to explore superconducting, magnetic, negative index, and nanoscopic materials. ***FY 2011 Accomplishments:*** Utilized implanted defect structures in diamond films to produce a system of addressable electron spin states that can be manipulated and entangled so that concepts in quantum information science may be tested at room temperature. Investigated nanoelectronic elements utilizing carbon nanotubes to form the basis for a new generation of sensors and circuit elements. Continued metamaterials research in coordination with Air Force laboratories to produce more efficient and smaller, omni-directional antennas. Continued search for new classes of superconductors to begin to produce several new superconducting materials that will be much more cost effective. ***FY 2012 Plans:***	8.234	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	42.865	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612306: *Materials*	30.681	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3002 in this Program Element (except the natural systems and extremophiles major thrust efforts moved to Project 3003) to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

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 manmade 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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	12.419	-	-	-	-
Description: Perform non-metallic, ceramic, and hybrid materials research to identify/design new materials and composites with very-high (above 1400 degrees Fahrenheit) and ultra-high (above 2500 degrees Fahrenheit) temperatures.					
FY 2011 Accomplishments: Investigated the impact of incorporation of carbon nanotubes in carbon fibers. Studied the incorporation of nano-particle incorporation in thermoplastic composites to improve its crystallization rate in filament winding conditions. Investigated the influence of nanoparticle networks within amorphous materials on high temperature mechanical properties. Continued modeling of interfacial properties between matrix and fiber in fiber reinforced composites.					
FY 2012 Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Perform research in metallic, ceramic and hybrid materials to understand their properties at temperatures above 1000 degrees Celsius. ***FY 2011 Accomplishments:*** Continued optimizing the thermal and mechanical stability of high temperature aerospace materials for air and space applications. Exploited new approaches to designing hybrid high temperature materials to enhance performance in harsh thermal environments. Further examined innovative concepts for developing stronger and more damage-tolerant high temperature hybrid materials. Further explored opportunities to reduce system weight and/or size, increased operational lifetime, and high temperature performance of aerospace structures. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	13.326	-	-	-	-
Title: Major Thrust 3. ***Description:*** Explore mimetics, natural materials, and natural/synthetic interfaces to enable development of novel sensors, engineering processes, and mechanisms. ***FY 2011 Accomplishments:*** Continued to manipulate materials to mimic the desirable properties found in autonomous materials for maintenance, self-healing, and repair. Continued to probe and manipulate chromophores and photoluminescent	4.936	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
characteristics in natural systems for applications to military sensor systems. Expanded the 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 ISR applications. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	30.681	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612307: *Fluid Mechanics*	25.579	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3002 in this Program Element (exception: the sensory information systems major thrust efforts moved to Project 3003) to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

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 remotely piloted aircraft (RPAs) 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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	8.940	-	-	-	-
Description: 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. ***FY 2011 Accomplishments:*** Characterized and modeled 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. Continued 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. Refined strategies for control of excessive heat transfer, unsteadiness, and separation in hypersonic flows to reduce severe local loads on systems. Developed multidisciplinary simulation capability for prediction of					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
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 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Expand fundamental knowledge of unsteady flows in integrated theoretical, experimental, and computational efforts. Study complex flow phenomena related to unsteady phenomena. ***FY 2011 Accomplishments:*** Developed physically accurate descriptions of unsteady flows over complex geometries and highly flexible structures. Derived and assessed reduced order models of canonical flow problems that lead to robust, closed loop flow control approaches. Refined modeling of promising flow control techniques to optimize fluid-structure interactions and aerodynamic efficiency for a wider range of flight operating conditions. Continue dvalidation of tools for predicting and controlling unsteady, vortex-dominated flows on RPAs in a range of scales. Developed numerical tools for multidisciplinary simulation of unsteady fluid-structure interactions. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	9.881	-	-	-	-
Title: Major Thrust 3. ***Description:*** Research novel sensing and control mechanisms applicable to small RPAs and low Reynolds Number flight regimes. Expand fundamental knowledge of natural flight control and navigation.	6.758	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
FY 2011 Accomplishments: Investigated natural flight capabilities applicable to multiple, coordinated air vehicles operating in cluttered and/or unpredictable environments. Developed 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 RPAs operating in low Reynolds Number regimes. Continued to develop mathematical and neuromorphic algorithms based upon sensorimotor information processing to enable new capabilities in autonomous flight. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	25.579	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612308: *Propulsion*	33.329	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3002 in this Program Element (exception: the bioenergy major thrust efforts moved to Project 3003) to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

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 spacebased 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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	12.246	-	-	-	-
Description: Research and model space propulsion and power in the areas of chemistry, electronics, miniaturization, and contamination/signature.					
FY 2011 Accomplishments: Continued 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. Continued investigation of nano-energetics in liquid and gel propellants to increase specific impulse in liquid propulsion systems, and studied the dynamic behavior of such systems, including three-phase, high-pressure, and temperature combustion phenomena. Continued investigating alternate launch systems using electromagnetic forces and beamed energy. Investigated new electric propulsion concepts for nano, micro, and macro satellites, including electrodeless and propellantless					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
systems, and power regeneration through thermoelectric materials. Conducted research on near-space propulsion alternatives, including air-breathing plasma propulsion systems. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Explore combustion, propulsion, and diagnostics in subsonics, supersonics, and hypersonics. Investigate multi-phase, turbulent reacting flows. ***FY 2011 Accomplishments:*** Continued 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. Continued research on the coupling between plasma chemistry and fuel combustion chemistry to understand ignition and combustion enhancement by plasmas. Continued 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, continued 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 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	14.218	-	-	-	-
Title: Major Thrust 3.	6.865	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Description: Identify, characterize, and bioengineer photosynthetic and/or non-photosynthetic microorganisms and their metabolic pathways. ***FY 2011 Accomplishments:*** Continued to study biosolar hydrogen research to redirect 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. Expanded 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. Continued research on microbial fuel cells that may potentially enhance power generation by exploring and characterizing newly discovered bacterial nanowires to understand their role in transporting electrons from microbial biofilms to electrodes. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	33.329	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
612311: *Information Sciences*	50.657	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, all efforts were moved from this Project to Project 3003 in this Program Element (exception: the sensing, surveillance, and navigation major thrust efforts moved to Project 3001) to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	11.351	-	-	-	-
Description: Conduct fundamental research in signals analysis for enhancement of sensing, surveillance, and targeting capabilities, increased awareness, and improved reaction/response. ***FY 2011 Accomplishments:*** Conducted research in innovative sensing and multi-modal data acquisition, and explored 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. Explored scientific issues connected with radar imaging (and target identification) including the determination of advantageous classes of transmit waveforms, for bistatic, multiple-output, or some other distributed set-up, together with the needed conceptual mathematics and computational techniques. Explored covertness and encryption requirements in “free-space” communication					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
including problems of information theory/optics whose solutions provide new methods of sequence key encryption. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Conduct research in complex systems and algorithms for highly flexible, reliable, secure, and rich information systems supporting battlefield commanders. ***FY 2011 Accomplishments:*** Increased emphasis on developing a science of cyber security. Developed new software systems modeling techniques that incorporate human behavioral models into software architectures to capture fundamental human-computer interaction. Initiated information operations research on artificial diversity. Expanded research on how fundamental mathematical methods translate into improved reliability and security of existing and future networks. Continued developing fundamental science of information integration and fusion that provides for situation and impact assessment to achieve predictive response. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	26.789	-	-	-	-
Title: Major Thrust 3. ***Description:*** Evaluate fundamental mechanisms and build mathematical descriptions of cognitive decisionmaking, including adaptation to non-cooperative interactions.	12.517	-	-	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
FY 2011 Accomplishments: Continued 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. Developed and tested algorithms for applications in reinforcement learning, sequential sampling, kernel-based classification and generalization, Bayesian forecasting, and optimization of attentional resources. Developed new techniques to understand, measure, and control informational masking to enhance speech communication and situational awareness. Investigated the fundamental constraints and limits of computationally-based socio-cultural prediction, including scalability from individual or small groups to larger coalitions. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	50.657	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613001: *Physics and Electronics*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
613001: *Physics and Electronics*	-	110.120	112.422	-	112.422	116.344	120.753	123.101	124.107	Continuing	Continuing

Note

Note: In FY 2012, all efforts from Projects 2301 and 2305 in this Program Element (PE) as well as the sensing, surveillance, and navigation major thrust effort in Project 2311 in this PE moved to this new Project to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

Note: In FY 2013, traditional laser efforts moved from Thrust 1 to Thrust 3 in this PE to more appropriately align the scientific disciplines.

A. Mission Description and Budget Item Justification

Basic research in the Physics and Electronics Project seeks to enable revolutionary advances in, and expand the fundamental knowledge supporting technologies critical to the future of the Air Force. 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. Major thrust areas being investigated in this Project are complex electronics and fundamental quantum processes; plasma physics and high energy density non-equilibrium processes; and lasers and optics, electromagnetics, communication, and signal processing. Although the major thrust descriptions that follow are specific sub-areas of focus within this Project, there is interest in exploring novel ideas that may bridge these major thrusts as well as those in the other Projects within this PE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	-	64.971	61.429	-	61.429
Description: Complex Electronics and Fundamental Quantum Processes: Scientific focus areas are atomic and molecular physics, optical physics, photonics, quantum electronic solids, adaptive multi-mode sensing and ultra-high speed electronics, semiconductor and electromagnetic materials, and optoelectronics.					
FY 2011 Accomplishments: N/A					
FY 2012 Plans: Explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, meta-materials, cathodes, di-electric and magnetic materials, semiconductor lasers, memristive systems, new classes of high-temperature superconductors, quantum dots, quantum wells and graphene. Includes research to understand mechanisms of generating and controlling quantum states, such as superposition and entanglement, in photons and ultra-cold atoms and molecules.					
FY 2013 Base Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613001: *Physics and Electronics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Explore a wide range of complex materials and devices, including non-linear optical materials, photonics, optoelectronics, meta-materials, cathodes, di-electric and magnetic materials, semiconductor lasers, memristive systems, new classes of high-temperature superconductors, quantum dots, quantum wells and graphene. Includes generating and controlling quantum states, such as superposition and entanglement, in photons and ultra-cold atoms and molecules. ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Plasma Physics and High Energy Density Non-Equilibrium Processes: Scientific focus areas are electro-energetic physics and space sciences. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Explore a wide range of activities characterized by processes sufficiently energetic to require the understanding and managing of plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Includes space weather, plasma control of boundary layers in turbulent flow, plasma discharges, radio frequency (RF) propagation, RF-plasma interaction, and high-power, beam-driven microwave devices. ***FY 2013 Base Plans:*** Explore a wide range of activities characterized by processes sufficiently energetic to require the understanding and managing of plasma phenomenology and the non-linear response of materials to high electric and magnetic fields. Includes space weather, plasma control of boundary layers in turbulent flow, plasma discharges, RF propagation, RF-plasma interaction, and high-power, beam-driven microwave devices. ***FY 2013 OCO Plans:*** N/A	-	14.316	14.615	-	14.615
Title: Major Thrust 3. ***Description:*** Lasers and Optics, Electromagnetics, Communication and Signal Processing Research: Scientific focus areas are physical mathematics and applied analysis, electromagnetics, remote sensing and imaging physics, and surveillance and navigation.	-	30.833	36.378	-	36.378

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613001: *Physics and Electronics*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
FY 2011 Accomplishments: N/A ***FY 2012 Plans:*** Explore all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Investigate aspects of the phenomenology of lasers including high energy lasers and non-linear optics. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals. ***FY 2013 Base Plans:*** Explore all aspects of producing and receiving electromagnetic and electro-optical signals, as well as their propagation through complex media, including adaptive optics and optical imaging. Investigate aspects of the phenomenology of lasers including high energy lasers and non-linear optics. Includes the development of sophisticated mathematics and algorithm development for extracting information from complex and/or sparse signals. ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	-	110.120	112.422	-	112.422

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613002: *Aerospace, Chemical and Material Sciences*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
613002: *Aerospace, Chemical and Material Sciences*	-	139.475	108.982	-	108.982	112.743	116.983	119.243	120.216	Continuing	Continuing

Note

Note: In FY 2012, all efforts from Projects 2302, 2303, 2306 (except the natural systems and extremophiles major thrust effort, which moved to Project 3003), 2307 (except the sensory information systems major thrust effort, which moved to Project 3003), and 2308 (except the bioenergy major thrust effort, which moved to Project 3003) in this Program Element (PE) moved to this new Project to more appropriately describe and align the changing focus of the scientific disciplines within the overall program.

Note: Decrease in FY 2013 due to higher Department of Defense priorities in Projects 3003 and 3004. The level of effort in each thrust will be reduced.

A. Mission Description and Budget Item Justification

Basic research in the Aerospace, Chemical, and Materials Sciences Project seeks to enable revolutionary advances in, and expand the fundamental knowledge supporting technologies critical to the future of the Air Force. 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. Major thrust areas being investigated in this Project are aero-structure interactions and control; energy, power, and propulsion; and complex materials and structures. Although the major thrust descriptions that follow are specific sub-areas of focus within this Project, there is interest in exploring novel ideas that may bridge these major thrusts as well as those in the other Projects within this PE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	-	34.868	27.245	-	27.245
Description: Aero Structure Interactions and Control: Scientific focus areas are high temperature aerospace materials, hypersonics, aerothermodynamics and turbulence, and flow interactions and control. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Investigate the characterization, modeling, and exploitation of interactions between the unsteady aerodynamic flow field and the dynamic					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613002: *Aerospace, Chemical and Material Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
air vehicle structure to enable enhanced performance in next generation Air Force systems. Explore the synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, structures, and thermodynamics. ***FY 2013 Base Plans:*** Investigate the characterization, modeling, and exploitation of interactions between the unsteady aerodynamic flow field and the dynamic air vehicle structure to enable enhanced performance in next generation Air Force systems. Explore the synergy gained from an interdisciplinary look at multiple technologies and the integration of core disciplines of fluid mechanics, structures, and thermodynamics. ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Energy, Power, and Propulsion: Scientific focus areas are thermal control, theoretical chemistry, molecular dynamics, space power and propulsion, and combustion and diagnostics. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, structures, and materials. Investigate processes associated with the generation, storage, and utilization of energy, specifically for Air Force systems. Includes developing novel energetic materials as well as understanding and optimizing combustion processes. ***FY 2013 Base Plans:*** Exploit technological innovations and develop potentially revolutionary technologies by integrating core disciplines of combustion, plasma dynamics, chemistry, hybrid simulation, structures, and materials. Investigates processes associated with the generation, storage, and utilization of energy, specifically for Air Force systems. Includes developing novel energetic materials as well as understanding and optimizing combustion processes. ***FY 2013 OCO Plans:*** N/A	-	46.027	35.964	-	35.964
Title: Major Thrust 3.	-	58.580	45.773	-	45.773

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613002: *Aerospace, Chemical and Material Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Description: Complex Materials and Structures: Scientific focus areas are mechanics of multifunctional materials and microsystems, multi-scale mechanics and prognosis, low density materials, and polymer chemistry. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Investigate multifunctional materials and structures composed of different classes of materials that may be able to change functionality or performance characteristics to enhance the mission versatility of future air and space systems, with a key goal of increasing functionality while decreasing weight and volume. Explore complex materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the meso-scale, ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility. ***FY 2013 Base Plans:*** Investigate multifunctional materials and structures composed of different classes of materials that may be able to change functionality or performance characteristics to enhance the mission versatility of future air and space systems, with a key goal of increasing functionality while decreasing weight and volume. Explore complex materials, microsystems, and structures that incorporate hierarchical design and functionality from the nano-scale through the meso-scale, ultimately leading to controlled, well-understood material or structural behavior capable of dynamic functionality and/or performance characteristics to enhance mission versatility. ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	-	139.475	108.982	-	108.982

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613002: *Aerospace, Chemical and Material 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 2013 Air Force			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613003: *Mathematics, Information and Life Sciences*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
613003: *Mathematics, Information and Life Sciences*	-	104.313	119.236	-	119.236	123.395	128.074	130.565	131.630	Continuing	Continuing

Note

Note: In FY 2012, all efforts from Projects 2304 and 2311 (except the sensing, surveillance, and navigation major thrust effort, which moved to Project 3001) in this Program Element (PE) moved to this new Project to more appropriately describe and align the changing focus of the scientific disciplines within the overall program. The natural systems and extremophiles major thrust effort in Project 2306, the sensory information systems major thrust effort in Project 2307, and the bioenergy major thrust effort in Project 2308 of this PE also moved to this new Project.

Note: In FY 2013, increased emphasis will be placed on complex networks, software, and decision making.

A. Mission Description and Budget Item Justification

Basic research in the Mathematics, Information, and Life Sciences Project seeks to enable revolutionary advances in, and expand the fundamental knowledge supporting technologies critical to the future of the Air Force. 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. Major thrust areas being investigated in this Project are information and complex networks, decision making, dynamical systems, optimization and control, and natural materials and systems. Although the major thrust descriptions that follow are specific sub-areas of focus within this Project, there is interest in exploring novel ideas that may bridge these major thrusts as well as those in the other Projects within this PE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	-	29.208	34.386	-	34.386
Description: Information and Complex Networks: Scientific focus areas are systems and software, information operations and security, information fusion, and complex networks. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Design and analyze techniques to enable reliable and secure exchange of information and predictable operation of networks and systems. Includes traditional aspects of information assurance, software engineering, and reliable systems, but the emphasis is on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Sub-areas					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613003: *Mathematics, Information and Life Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
include system and network performance prediction, design and analysis, and modeling of human-machine systems. ***FY 2013 Base Plans:*** Design and analyze techniques to enable reliable and secure exchange of information and predictable operation of networks and systems. Includes traditional aspects of information assurance, software engineering, and reliable systems, but the emphasis is on the underlying mathematics of secure-by-design architectures of networked communications and neural information processing. Sub-areas include system and network performance prediction, design and analysis, and modeling of human-machine systems. ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Decision Making: Scientific focus areas are mathematical modeling of cognition and decision making, and collective behavior and socio-cultural modeling. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Investigate new mathematical laws, scientific principles, and robust algorithms that underlie intelligent, mixed human-machine decision making to achieve accurate real-time projection of expertise and knowledge into and out of the battlespace. Includes efforts to advance the critical knowledge base in information sciences and information fusion, and to model individual and group cognitive processing and decision making. ***FY 2013 Base Plans:*** Investigate new mathematical laws, scientific principles, and robust algorithms that underlie intelligent, mixed human-machine decision making to achieve accurate real-time projection of expertise and knowledge into and out of the battlespace. Includes efforts to advance the critical knowledge base in information sciences and information fusion, and to model individual and group cognitive processing and decision making. ***FY 2013 OCO Plans:*** N/A	-	14.604	18.693	-	18.693
Title: Major Thrust 3.	-	39.638	42.309	-	42.309

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613003: *Mathematics, Information and Life Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Description: Dynamical Systems, Optimization, and Control: Scientific focus areas are computational mathematics, dynamics and control, and optimization and discrete mathematics. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Develop new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and design complex multi-scale systems as well as provide guaranteed levels of performance. Includes study of novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments. ***FY 2013 Base Plans:*** Develop new scientific concepts supported by rigorous analysis for advancing the science of autonomy and promoting the understanding necessary to analyze and design complex multi-scale systems as well as provide guaranteed levels of performance. Includes study of novel adaptive control strategies for coordinating heterogeneous, autonomous, or semi-autonomous aerospace vehicles in uncertain, information rich, dynamically changing, adversarial, and networked environments. ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 4. ***Description:*** Natural Materials and Systems: Scientific focus areas are renewable energy, natural materials and nature inspired systems. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Investigate multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems accomplish their required tasks. Study how to adapt and mimic existing natural sensory systems	-	20.863	23.848	-	23.848

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613003: *Mathematics, Information and Life Sciences*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
and add existing capabilities to these organisms with the intent to gain more precise control over their material production. ***FY 2013 Base Plans:*** Investigate multi-disciplinary approaches for studying, using, mimicking, synthesizing and adapting to the ways natural systems accomplish their required tasks. Study how to adapt and mimic existing natural sensory systems and add existing capabilities to these organisms with the intent to gain more precise control over their material production. ***FY 2013 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	-	104.313	119.236	-	119.236

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613004: *Education and Outreach*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
613004: *Education and Outreach*	-	10.420	21.147	-	21.147	21.785	22.394	22.875	23.255	Continuing	Continuing

Note

Note: In FY 2012, all efforts from Project 4113 in this Program Element moved to this new Project to more appropriately describe and align the changing focus of outreach development within the overall program.

Note: In FY 2013, increased emphasis will be placed on international collaborations, the National Research Council Resident Research Program and the Summer Faculty Research Program.

A. Mission Description and Budget Item Justification

The major thrust areas in this Science & Technology (S&T) Outreach Development 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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1.	-	5.238	9.935	-	9.935
Description: Outreach to International S&T Community: Foster international S&T cooperation by supporting direct interchanges with a broad range of key international researchers and communities. Identify and leverage international scientific advances when appropriate.					
FY 2011 Accomplishments: N/A					
FY 2012 Plans: Leverage international expertise and support international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Explore current foreign investments and influence world-class scientific research on specific topics of Air Force interest. Pursue access to technical information on foreign research capabilities within our interests. Support international visits by scientists and high-level					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613004: *Education and Outreach*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Department of Defense (DoD) S&T delegations, and provide primary interface to coordinate international S&T participation among DoD organizations. ***FY 2013 Base Plans:*** Leverage international expertise and support international technology liaison missions to identify and maintain awareness of foreign science and technology developments. Explore current foreign investments and influence world-class scientific research on specific topics of Air Force interest. Pursue access to technical information on foreign research capabilities within our interests. Support international visits by scientists and high-level Department of Defense (DoD) S&T delegations, and provide primary interface to coordinate international S&T participation among DoD organizations. ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2. ***Description:*** Outreach to U.S. S&T Workforce: Strengthen science, mathematics, and engineering research and educational infrastructure in the U.S., thereby strengthening current and future Air Force S&T capabilities. ***FY 2011 Accomplishments:*** N/A ***FY 2012 Plans:*** Increase awareness of Air Force research needs and opportunities throughout the civilian scientific community, while simultaneously identifying, recruiting, and increasing opportunities for new young investigators to participate in critical Air Force research. 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. ***FY 2013 Base Plans:*** Increase awareness of Air Force research needs and opportunities throughout the civilian scientific community, while simultaneously identifying, recruiting, and increasing opportunities for new young investigators to participate in critical Air Force research. 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. ***FY 2013 OCO Plans:***	-	5.182	11.212	-	11.212

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 1: *Basic Research*	R-1 ITEM NOMENCLATURE PE 0601102F: *Defense Research Sciences*	PROJECT 613004: *Education and Outreach*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
N/A					
Accomplishments/Planned Programs Subtotals	-	10.420	21.147	-	21.147

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

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 2013 Air Force			DATE: February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
614113: *External Research Programs Interface*	9.277	-	-	-	-	-	-	-	-	Continuing	Continuing

Note

Note: In FY 2012, as part of the realignment of the overall Program to reflect the changing focus of the scientific disciplines, this Project was renamed Education and Outreach - Project 3004 to more appropriately describe its mission.

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Title: Major Thrust 1	5.141	-	-	-	-
Description: Foster international science and technology cooperation by supporting the Air Force's international strategy mission. Identify and leverage unique foreign research capabilities.					
FY 2011 Accomplishments: Leveraged international expertise and supported international technology liaison missions in identifying and maintaining awareness of foreign science and technology developments. Capitalized on foreign investments by influencing and acquiring world-class scientific research. Found and maintained access to technical briefs and publications on unique foreign research capabilities. Supported international visits of high-level Department of Defense (DoD) delegations. Provided primary interface to coordinate international participation among DoD organizations.					
FY 2012 Plans: N/A					
FY 2013 Base Plans:					

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
N/A ***FY 2013 OCO Plans:*** N/A					
Title: Major Thrust 2 ***Description:*** Strengthen science, mathematics, and engineering research as well as educational infrastructure in the U.S., thereby strengthening Air Force technical capabilities. ***FY 2011 Accomplishments:*** Increased awareness of Air Force research needs throughout civilian scientific community. Identified and recruited the best scientific talent to participate in critical Air Force research. 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. ***FY 2012 Plans:*** N/A ***FY 2013 Base Plans:*** N/A ***FY 2013 OCO Plans:*** N/A	4.136	-	-	-	-
Accomplishments/Planned Programs Subtotals	9.277	-	-	-	-

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• N/A: *N/A*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2013 Air Force		DATE: February 2012
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*

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.