RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)

DATE: February 2003

BUDGET ACTIVITY: 01 - Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	221,683	217,863	204,754	218,188	232,030	257,669	246,689	249,160	Continuing	TBD
2301	Physics	23,481	24,180	22,769	23,795	24,064	27,431	24,945	25,272	Continuing	TBD
2302	Solid Mechanics and Structures	11,152	11,567	11,741	11,744	11,868	12,080	12,273	12,456	Continuing	TBD
2303	Chemistry	28,084	28,810	27,178	29,902	30,703	34,149	31,336	31,766	Continuing	TBD
2304	Mathematical and Computer Sciences	34,200	32,211	29,625	33,383	34,231	37,741	38,723	39,237	Continuing	TBD
2305	Electronics	26,809	23,918	23,856	25,280	27,001	29,383	29,793	30,183	Continuing	TBD
2306	Materials	15,946	14,608	15,164	17,598	19,223	21,457	20,771	20,079	Continuing	TBD
2307	Fluid Mechanics	9,705	10,320	10,985	11,901	12,024	12,241	12,437	12,623	Continuing	TBD
2308	Propulsion	22,060	23,216	13,245	13,774	21,851	22,208	22,563	22,903	Continuing	TBD
2311	Space Sciences	16,293	15,123	15,654	16,268	16,446	19,670	17,984	18,235	Continuing	TBD
2312	Biological Sciences	13,535	14,005	14,352	14,720	14,879	18,072	15,389	15,621	Continuing	TBD
2313	Human Performance	14,097	12,700	12,776	12,218	12,337	15,489	12,767	12,958	Continuing	TBD
4113	External Research Programs Interface	6,321	7,205	7,409	7,605	7,403	7,748	7,708	7,827	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences

(U) A. Mission Description

This program comprises 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 projects are coordinated through the Defense Reliance process to harmonize efforts, eliminate duplication, and ensure the most effective use of funds across the Department of Defense. All research areas are subject to long-range planning and technical review by both Air Force and tri-Service scientific planning groups. Note: In FY 2003, Congress added $1.923 million for the Center for Adaptive Optics and $2.5 million for Coal-Based Jet Fuel.

(U) B. Budget Activity Justification

This program is Budget Activity 1, Basic Research, because it funds scientific study and experimentation. Through this program, the Air Force invests in research directed toward increasing knowledge and understanding in those fields of science and engineering related to long-term national security needs.

(U) C. Program Change Summary ($ in Thousands)

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	226,322	219,144	228,597	
(U)	Appropriated Value	228,419	223,744		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-2,097	-3,591		
	b. Small Business Innovative Research	-5,057			
	c. Omnibus or Other Above Threshold Reprogram		-2,290		
	d. Below Threshold Reprogram	1,500			
	e. Rescissions	-1,082			
(U)	Adjustments to Budget Years Since FY 2003 PBR			-23,843	
(U)	Current Budget Submit/FY 2004 PBR	221,683	217,863	204,754	TBD

(U) Significant Program Changes:

Changes to this program since the previous President's Budget are a result of emphasis on other programs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences / PROJECT: 2301

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2301	Physics	23,481	24,180	22,769	23,795	24,064	27,431	24,945	25,272	Continuing	TBD

(U) A. Mission Description

Physics research aims to revolutionize advances in laser technologies, sensors and imaging, miniature satellites, and communications to allow superior strategic awareness. It expands fundamental knowledge of optics, electromagnetics, as well as microwaves and plasmas. The goals are to enable and enhance technologies critical to Air Force lasers, optics, avionics, and microwaves and to improve technologies associated with non-intrusive/non-destructive testing and analysis. Research topics focus on revolutionary improvements in electromagnetic countermeasures, protection against nuclear weapons effects, communications, small satellites, and novel sensors. The primary areas of research investigated by this project are laser and optical physics; atomic, molecular, and imaging physics; senor/space environment interactions; and plasma physics.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $9,687 Performed laser and optical physics research for new concepts in solid state lasers, especially fiber lasers, to attain compact, inexpensive modules in the one kilowatt average power range. The results of this research further enabled spoofing and fatal damage of infrared-seeking missiles and improved high performance radars. Studied techniques for integrating modules to achieve multiple power levels at affordable cost and useful size for application to airborne or space platforms. Investigated concepts for achieving very high resolution of deep space objects using very large aperture adaptive telescopes. Explored novel low-cost light sources for high-power ultraviolet lasers capable of high intensity and spectral brightness for disinfection of biological agents, the synthesis of chemical agents, and safely stripping aircraft paint.

(U) $7,554 Continued to conduct research in plasma physics to investigate fundamental interactions between charged particles and electromagnetic fields for future affordable low-observables and space communications/surveillance. Explored physics relating to the power-efficient production and maintenance of substantial volumes of low-temperature plasma at atmospheric pressures for plasma-based aerodynamic drag reduction. Investigated the controlled resistive, conducting, and dielectric behavior of plasmas, and the effects of plasmas on absorption, reflection, and transmission of electromagnetic waves to create new stealth aircraft mechanisms. Examined the viability of using collisional ionized gas volumes to shield friendly assets.

(U) $4,308 Studied atomic, molecular, and imaging physics to evaluate the interaction of atoms, molecules, and ions for use in improved explosives and fuels, enhanced space surveillance, superior communications, precision navigation, and the neutralization of biological threats. Continued efforts to quantify interactions of atoms in strong electromagnetic fields so as to enable novel lasers for Air Force applications. Continued research on isomeric, very high density energy storage for flash radiation devices to diminish or eliminate refueling on long endurance flights.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2301

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

Further investigated the use of holographic films for correction of distortion and aberration in space surveillance telescopes.

(U) $1,932 Continued to enhance the research performance of the new 30-meter infrared adaptive optical telescope at the Center for Astronomical Active Optics. Continued research studies on adaptive optics to enable adaptive telescopes for laser beam projection into space, space reconnaissance, space power collectors, and space-based lasers.

(U) $23,481 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $9,441 Explore laser and optical physics to study the effect of combining high power solid state lasers with integrated nonlinear and pulse forming optics. Study concepts to achieve high output powers at wavelengths required for space applications. Continue studies of large aperture adaptive telescopes for very high resolution deep space imaging. Explore large, lightweight adaptive optics for space surveillance applications. Study laser micro-machining techniques for producing specialized space micro-systems for multi-functional micro- and nano-satellites.

(U) $8,133 Conduct research in plasma physics to investigate fundamental interactions between charged particles and electromagnetic fields for future directed energy weapons, affordable low-observables, and space communications and surveillance. Explore physics topics relating to the dynamic molecular interactions in combustion and high energy density propellants. Examine the detailed physics of material, surface, and air breakdown in the presence of strong electric fields. These fundamental findings will facilitate creation of more compact, lighter weight, portable pulsed power systems to power future directed energy weapon systems.

(U) $4,646 Study atomic, molecular, and imaging physics to evaluate the interaction of atoms, molecules, and ions to provide basic information to improve explosives and fuels, enhanced space surveillance, superior communications, precision navigation, and the neutralization of biological threats. Investigate fundamental interplay between atoms and strong electromagnetic fields to create new classes of lasers for Air Force applications. Develop isomeric, high energy density storage for flash radiation devices to diminish or eliminate refueling requirements on long endurance flights. Continue basic research of holographic films for correction of distortion and aberration in space surveillance telescopes. Measure ultraviolet emission cross sections from electron impact to provide fundamental data needed in satellite surveillance.

(U) $1,960 Enhance the research performance of the 30-meter infrared adaptive optical telescope at the Center for Astronomical Active Optics. Expand research studies on adaptive optics to further enable adaptive telescopes for laser beam projection into space, space reconnaissance, space power collectors, and space-based lasers.

(U) $24,180 Total

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BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
01 - Basic Research	0601102F Defense Research Sciences	2301

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$10,181	Expand studies of high power fiber lasers, in particular those using novel material combinations, which support large-core, single-mode fibers. Study direct and nonlinear optical methods for combining beams of fiber lasers to achieve power levels needed for multiple directed energy applications. Continue research to convert wavelengths of high-power laser arrays to values needed for space applications and aircraft protection. Extend studies of large aperture adaptive telescopes for very high-resolution deep space imaging. Continue large, lightweight adaptive optics studies for space surveillance applications. Study new optical techniques to achieve very large aperture, very wide-band phased array radars in space.
(U)	$8,012	Enhance research studies in plasma physics to probe the fundamental interactions between charged particles and electromagnetic fields for all-electric military platforms, high-bandwidth communications, advanced long-distance covert surveillance, and space communications and surveillance. Explore physics topics relating to the dynamics of molecular interactions in combustion and high energy density propellants. Examine the detailed physics of material, surface, and air breakdown in the presence of strong electric fields. Exploit fundamental findings to facilitate creation of more compact, lighter weight, portable pulsed power systems in order to power future directed energy weapons. Expand the frontiers of understanding the effects of short-pulse intense electric fields on biological cells.
(U)	$3,281	Conduct research on the interaction of systems and sensors with the air and space environments. Investigate means to expand models of sensor performance to incorporate measurements of terrestrial and space backgrounds and radiation. Continue the study of methods to enhance hyperspectral imagery using polarization and hypertemporal information. Develop models to predict the atmospheric effects on laser propagation. Examine methods of using holographic techniques for dynamic correction of distortion and aberration in space surveillance telescopes.
(U)	$1,295	Study atomic, molecular, and imaging physics to evaluate the interaction of atoms, molecules, and ions to improve explosives and fuels, enhance surveillance, provide superior communications, improve precision navigation, and neutralize biological threats. Continue investigation into the fundamental interplay between atoms and strong electromagnetic fields to create new classes of lasers for Air Force applications. Explore uses for laser cooled and trapped atoms. Expand development of isomeric, high energy density storage for flash radiation devices that will diminish or eliminate refueling requirements on long endurance flights. Continue measurement of ultraviolet emission cross sections from electron impact to provide fundamental data needed in satellite surveillance.
(U)	$22,769	Total

(U) B. Project Change Summary

Not Applicable.

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BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences
PROJECT: 2301	

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

(U) Related Activities:

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0602204F, Aerospace Sensors.

(U) PE 0602500F, Multi-Disciplinary Space Technology.

(U) PE 0602601F, Space Technology.

(U) PE 0602605F, Directed Energy Technology.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences / PROJECT: 2302

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2302	Solid Mechanics and Structures	11,152	11,567	11,741	11,744	11,868	12,080	12,273	12,456	Continuing	TBD

(U) A. Mission Description

Solid Mechanics and Structures basic research aims to dramatically improve the behavior of air and space materials and structures via better description of wear and damage dynamics. The research expands the fundamental knowledge of the aeroelastic and acoustic behavior of airframes and engine structures, as well as the fluid behavior of launch vehicles and space structures. The goals are cost-effective development and safe, reliable operation of superior Air Force weapons and defensive systems for assured global reach and air and space persistence. Research topics include: designing advanced material structures on the micro- and nano-scale; modeling and simulation of the dynamic behavior of aircraft, missiles, and large space structures; and technology integration for the performance and survivability enhancement of these systems. The primary areas of research investigated by this project are mechanics of composite materials, structural mechanics, and structural dynamics.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,340 Further studied mechanics of materials to accelerate utilization of advanced materials such as composites, high-temperature alloys, and ceramic matrix composites in air and space vehicles, turbine engines, space systems, and weapon systems. Explored synergistic combinations of information technology and multi-scale modeling to design new materials and new structures. Continued to explore nanomechanics to bridge the gap between continuum mechanics and atomistic modeling. Further probed theoretical foundations for multi-functional mechanics, including nonlinear behavior, to enable the development of multi-functional structures used in advanced space systems such as micro-satellites and micro-vehicles.

(U) $4,846 Conducted research into structural and material aspects of high-cycle metal fatigue and other aging mechanisms of aircraft. Continued to develop techniques for predictive computer simulation of structural response. Explored research into metal fatigue-generation due to vibration of jet engine compressor and turbine blades and the interaction of blade motion with fluid mechanics. Studied material science to identify and mitigate material degeneration in a timely and cost-efficient manner. Enhanced techniques to analyze vehicle integrity and significantly increase the structural longevity of Air Force weapon systems.

(U) $3,966 Conducted structural mechanics research to examine innovative adaptive structure concepts for deployment of space-based systems and multi-mission uninhabited air vehicles. Continued to evaluate the behavior of distributed sensor and actuator systems to improve the design and performance prediction of air and space systems. Furthered research into predictive techniques capable of modeling the interaction of structural motion with high-speed aerodynamics characteristic of uninhabited air vehicles. Continued investigating the mechanical and dynamic behavior of micro-scale structures to enable micro-electro-mechanical systems that can sense environments and respond accordingly (smart structures).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences
PROJECT 2302	

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U) $11,152 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,540 Research mechanics of advanced materials to accelerate their use as composites, high-temperature alloys, and ceramic matrix composites. Results will have direct application in air and space vehicles, turbine engines, space systems, and weapon systems. Develop methods to synergistically combine multi-scale modeling and information technology to design new materials and structures. Establish foundations of nanomechanics that transition between continuum mechanics and atomistic modeling. Apply multi-functional mechanics with nonlinear behavior to design multi-functional materials and structures used in advanced air and space systems such as micro-satellites and micro-vehicles.

(U) $4,672 Research the structural and material aspects of high-cycle metal fatigue and other aging mechanisms of aircraft. Develop fundamental computer simulations to predict structural response to assorted stimuli. Explore metal fatigue-generation caused by vibration of compressor and turbine blades and blade motion/fluid flow coupling. Study material science to quickly and inexpensively identify and mitigate material degeneration and degredation. Develop novel system techniques to analyze vehicle integrity to significantly increase the robustness of Air Force weapon systems.

(U) $4,355 Conduct structural mechanics research to examine innovative adaptive structure concepts for deployment of space-based systems and multi-mission unmanned aerial vehicles (UAV). Investigate the behavior of distributed sensor and actuator systems to improve the design and performance characterization of air and space systems. Develop models to predict the interaction between structural motion and high-speed aerodynamics characteristic of UAVs. Exploit the mechanical and dynamic behavior of micro- and nano-scale structures to achieve exceptional capabilities in micro-electro-mechanical systems and nano-electro-mechanical systems.

(U) $11,567 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,478 Enhance research in the mechanics of advanced materials to accelerate their use as composites, high-temperature alloys, and ceramic matrix composites. Continue development of methods to combine multi-scale modeling and information technology to design new materials and structures. Further examine the foundations of nanomechanics in transitioning between continuum mechanics and atomistic modeling. Continue to apply multi-functional mechanics with nonlinear behavior to enhance design of multi-functional materials and structures used in advanced air and space systems such as micro-satellites and micro-vehicles.

(U) $5,015 Investigate structural and material aspects of high-cycle metal fatigue and other aging mechanisms of aircraft. Expand and enhance fundamental

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BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2302

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

computer simulations to predict structural response to assorted stimuli. Continue to explore metal fatigue-generation caused by vibration of compressor and turbine blades and blade motion/fluid flow coupling. Explore material science research to quickly and inexpensively identify and mitigate material degeneration and degradation. Continue to develop novel system techniques to analyze vehicle integrity to significantly increase the robustness of Air Force weapon systems and allow effective air and space persistence.

(U) $4,248 Continue research studies in structural mechanics to examine innovative adaptive structure concepts for deployment of space-based systems and multi-mission unmanned aerial vehicles (UAVs). Further probe the behavior of distributed sensor and actuator systems to improve the design and performance characterization of air and space systems. Expand models to predict the interaction between structural motion and high-speed aerodynamics characteristic of UAVs. Exploit the mechanical and dynamic behavior of micro- and nano-scale structures to achieve exceptional capabilities in micro-electro-mechanical systems and nano-electro-mechanical systems.

(U) $11,741 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602202F, Human Effectiveness Applied Research.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0603211F, Aerospace Structures.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences / PROJECT: 2303

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2303	Chemistry	28,084	28,810	27,178	29,902	30,703	34,149	31,336	31,766	Continuing	TBD

(U) A. Mission Description

Chemistry 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 lasers; the infrared, optical, and radar signatures of reaction products and intermediates that advance reliable target assessment and tracking; and the synthesis of new chemical propellants that allow space access and assured operations. Critical research topics include: novel synthesis and characterization of lower cost, higher performance functional and structural materials, electronics, and photonic materials; nano-structures; electromagnetic and conventional weaponry; and propellants. Focused investigations include the effects of chemical and morphological structures on functional and mechanical properties of polymeric materials and the exploration of atomic and molecular surface interactions that limit performance of electronic devices, compact power sources, and lubricant materials. Primary areas of research include molecular dynamics and theoretical chemistry, polymer chemistry, and surface and interfacial science.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $11,505 Performed molecular dynamics and theoretical chemistry research to identify and predict techniques to control molecular reactivity and energy flow, and developed predictive tools for designing new materials and processes for advanced propellants. Sought understanding of mechanisms of using ion and plasma chemistry to reduce drag and/or enhance combustion. Continued to synthesize novel chemical monopropellants for satellite and rocket applications. Further explored the gain and loss mechanisms in chemical laser systems to permit operation at higher powers. Identified inputs required to model chemically reacting flows in rocket plumes. Further developed theoretical methods to predict properties of structural materials.

(U) $8,891 Conducted polymer chemistry research to improve fundamental understanding of chemical structures and processing conditions to develop advanced polymeric materials for significantly improved Air Force systems performance and life spans. Explored chemistry concepts based on organic materials that will enable protection of Air Force personnel and sensors from agile lasers. Investigated nanocomposites to improve thermal and mechanical properties of polymers for lightweight aerospace structures. Probed means to control nanostructure assembly to attain new photonic and electronic functions.

(U) $5,755 Studied the chemistry of surface and interfacial processes for accurate detection and prevention of corrosion and degradation of air and space systems, and development and design of novel lubricants. Developed new long-life, low-friction surface structures and coatings for terrestrial

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PROJECT 2303	

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

and space environments. Examined environmentally compliant nanostructured coating systems for corrosion protection of aluminum aircraft. Investigated novel three-dimensional surface nanostructures for sensor, optical, and power applications. Continued examinations of nano-scale surface structures with enhanced energy densities for significantly improved weapon system energy storage and delivery. Furthered development of theoretical and predictive methods for surface and interfacial chemical processes.

(U) $1,933 Conducted research in chemical synthesis and detection techniques, chemical theory, and modeling and simulation that will ultimately lead to breakthroughs in new fuels and rocket propellants that are environmentally benign, have reduced signatures, and are less sensitive to accidental detonations. Investigated lifecycle applications of these potential fuels in flight vehicles. Studied application of any potential fuels breakthroughs to the development of hydrocarbon-fueled scramjets and combined-cycle engines for space applications.

(U) $28,084 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $11,051 Conduct molecular dynamics and theoretical chemistry research to identify and predict techniques to control molecular reactivity and energy flow. Results will enable development of next generation predictive tools for designing new materials and processes for advanced, super energetic propellants. Explore uses of ion and plasma chemistry for flow control applications. Model interactions between aerospace systems and the space environment. Investigate concepts of reactive energetic nano-structures for applications to propulsion and munitions. Develop and validate theoretical methods to predict and design behavior and properties of nano-structures. Model chemically reacting flows associated with hypersonic vehicles. Research new chemical sources of electronic excited states needed to fuel chemical laser systems.

(U) $9,547 Explore polymer chemistry sciences to improve fundamental understanding of chemical structures, reactivity, and processing conditions to develop advanced polymeric materials. Research findings aimed at significantly improving Air Force systems performance and life-spans. Explore magnetic, conductive, and optical properties of coating materials to achieve smart skin concepts with on-demand tunable properties. Investigate biologically inspired polymer concepts to achieve enhanced photonic properties and photonic bandgap structures. Explore molecular conformational changes to achieve controllable mechanical actuation in polymeric materials. Exploit transportable large optics technology.

(U) $6,176 Investigate the chemistry of surface and interfacial processes for accurate detection and prevention of corrosion and degradation of air and space systems. Explore physical properties of novel lubricants. Create new low-friction, long-life coatings and surface structures for terrestrial and space environments. Research novel three-dimensional surface nano-structures for sensor, optical, and power applications. Probe nano-scale surface structures with enhanced energy densities for better weapon system energy storage and delivery. Develop theoretical and predictive methods for surface and interfacial chemical processes.

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01 - Basic Research	0601102F Defense Research Sciences	2303

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

(U)	$2,036	Research novel chemical synthesis and detection techniques, chemical theory, and modeling and simulation focused on revolutionary breakthroughs in new fuels and rocket propellants that are more energetic, are environmentally benign, have reduced signatures, and are less sensitive to accidental detonations. Identify and investigate applications of these potential fuels in flight vehicles so as to enhance the benefits of increasing mass of payloads put into space and increasing the lifetime of satellites on orbit. Study application of any potential fuels breakthroughs to the development of hydrocarbon-fueled scramjets and combined-cycle engines for space applications.
(U)	$28,810	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$11,885	Further molecular dynamics and theoretical chemistry research to identify and predict techniques to control molecular reactivity and energy flow. Results will enable the next generation of predictive tools for designing new materials and processes for advanced, super-energetic propellants and countermeasure techniques. Probe novel chemical synthesis and detection techniques, chemical theory, and modeling and simulation focused on fostering revolutionary breakthroughs leading to fuels and rocket propellants that are more energetic, environmentally benign, less sensitive to accidental detonations, and emit reduced signatures. Optimize properties of these potential fuels to increase the mass of payloads that can be put into space and to increase the lifetime of satellites on orbit. Study the fundamental behavior of these new fuels in hydrocarbon-fueled scramjets and combined-cycle engines for space applications. Explore uses of ion and plasma chemistry for combustion control applications. Model the chemical interactions between air and space systems and the space environment. Investigate concepts of reactive energetic nano-structures for enabling advances in munitions and propulsion systems leading to benefits such as safer penetrating munitions and enhanced spacecraft payload fractions. Develop and validate theoretical methods to predict and design the behavior and properties of nano-structures. Enhance models of chemically reacting flows associated with hypersonic vehicles. Research new chemical sources of electronic excited states needed to fuel chemical laser systems.
(U)	$9,286	Conduct polymer chemistry research to improve fundamental understanding of chemical structures, reactivity, and processing conditions to develop advanced polymeric materials aimed at significantly improving Air Force systems performance and life-spans to allow effective air and space persistence. Explore flexible structures that can provide functions such as sensing, power generation and storage, electronics and electronic memory for integration into multi-functional structures. Develop organic molecules with high optical nonlinearities for protection against laser threats. Improve electro-optic polymers for improved performance for photonic radar development. Research organic-based electronics for multi-functional integration.
(U)	$6,007	Critically examine the chemistry of surfaces and interfacial processes for the rapid and accurate detection of corrosion and degradation of air and

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BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
01 - Basic Research	0601102F Defense Research Sciences	2303

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

space systems. Assemble novel multi-functional coatings for the corrosion protection of aging aircraft. Explore the chemical and physical properties of novel lubricants for terrestrial and space environments. Develop low-friction, long-life multi-functional surface structures and coatings for micro- and nano-electromechanical systems. Exploit chemically directed self-assembly to produce novel three-dimensional surface nano-structures for sensor, optical, and power applications. Probe nano-scale surface structures with enhanced energy-densities for better weapon system energy storage and delivery. Continue to improve theoretical and predictive methods for surface and interfacial chemical processes.

(U) $27,178 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0602602F, Conventional Munitions.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences — PROJECT: 2304

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2304	Mathematical and Computer Sciences	34,200	32,211	29,625	33,383	34,231	37,741	38,723	39,237	Continuing	TBD

(U) A. Mission Description

Mathematical and computer sciences 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, complex systems software, physical mathematics and applied analysis, optimization and discreet mathematics, computational mathematics, and signals communication and surveillance.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,776 Performed dynamics and control research to develop new techniques for design and analysis of control systems to significantly enhance capabilities and performance of air and space vehicles. Expanded programs on cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unmanned vehicles, and constellations of small satellites. Further developed novel techniques for the control of nonequilibrium behavior of complex, unsteady fluid systems (chemically reacting flows) with applications to combustion and materials processing.

(U) $6,776 Conducted research in complex systems and software, artificial intelligence, automatic knowledge acquisition; study high performance knowledge bases to allow rigorous construction of highly complex battlefield information systems. Identified advanced techniques in intelligent and mobile agents for next generation information systems. Conducted research in information operations, including support for language-based security, mobile code security, protected execution, and dynamic, adaptive intrusion detection for protection of future battlespace and infosphere systems and networks.

(U) $6,452 Conducted physical mathematics/applied analysis and electromagnetics research to devise accurate models of physical phenomena to enhance controls and signal processing techniques. Investigated the feasibility of coherently propagating short laser pulses through the air for superior accuracy in laser-guided munitions. Enhanced models to predict nonlinear optical effects within semiconductor lasers and through other nonlinear optical media for applications in laser beam control and stability. Expanded formulation of optimal electromagnetic wave propagation/scattering codes to provide accurate and timely target recognition. Evaluated methods to penetrate tree cover and recognize targets with wide band radar. Investigated feasibility of incorporating virtual time-reversal methodology onboard a formation of small satellites to enhance imaging of radar-acquired moving targets.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences	PROJECT: 2304

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

(U)	$4,517	Studied optimization and discrete mathematics to devise advanced mathematical methods for solving complex problems in logistics, engineering design, and strategic planning for battlespace information management. Expanded algorithmic research which produces a feasible solution within the time constraint of military operations. Developed techniques for hierarchical model building to accommodate multiple levels of aggregation and complexity, to reflect time and computational constraints.
(U)	$3,549	Performed computational mathematics research to devise unique simulations and designs of advanced Air Force systems. Integrated new multi-disciplinary design optimization strategies with high-order, time-accurate solvers for superior design of jet engines, aircraft wings, munitions, along with other air and space components. Investigated efficient methods to quantify uncertainty in nonlinear multi-disciplinary design models. Continued devising methods to reduce computation time for chemical simulations from months to days. Improved algorithms for plasma dynamics simulations, munition penetration simulations, and ground-based image reconstruction.
(U)	$2,583	Studied signals communication and surveillance to expand quantitative methodologies that extend the capability of critical mobile, networked communications systems, and strengthen the performance of surveillance and targeting functions. Improved the efficiency of source-channel coding in wireless communication through technical advances such as optical transmission. Continued research in probabilistic and analytic theory to achieve higher information rates and greater reliability under stringent military covertness constraints. Further developed promising areas such as super-resolution imaging and trellis-coded modulation.
(U)	$1,933	Constructed quantum computer devices that enable atomic level computing a million times faster than silicon chip. Designed, implemented, and tested quantum computing algorithms and architectures enabling fast, accurate solutions of complex fluid dynamics problems eliminating the need for multiple design iterations and prototype testing. Developed scalable quantum computers for automatic target recognition and target characterization.
(U)	$1,614	Explored mathematical and computational methods of external aerodynamics associated with hypersonic weapon release. Expanded plasma aerodynamics algorithms to include magneto hydrodynamic augmentation of complete scramjet engines. Computationally investigated the effects of dynamic air and space structural tailoring during combat maneuvers on end-game targeting. Computationally explored hypersonic boundary layer transition on transatmospheric vehicles to reduce heat transfer and viscous drag to enable long-range, high-payload hypersonic vehicles.
(U)	$34,200	Total

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BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences
PROJECT: 2304	

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$6,480	Perform dynamics and control research to develop new techniques for design and analysis of control systems. Research findings will significantly enhance capabilities and performance of air and space vehicles. Focus of the research is on cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unmanned aerial vehicles (UAVs), and constellations of small satellites. Explore means to improve control of nonequilibrium behavior of complex, unsteady fluid systems (chemically reacting flows) with applications to combustion and materials processing. Foster advances in image processing and sensor technology that can be utilized in controller design for UAVs, smart munitions, nondestructive testing of aging or stealth air and space vehicles. Design computational models to analyze biological processes for adaptation to air and space systems.
(U)	$6,480	Conduct research in complex systems and software, artificial intelligence, automatic knowledge acquisition, and high performance knowledge bases to allow rigorous construction of highly complex battlefield information systems. Explore methods to enhance research in information operations, including support for language-based security, mobile code security, protected execution, and dynamic, adaptive intrusion detection for protection of future battlespace/infosphere systems and networks. Develop new computational techniques/software in extremely large (10,000,000+ axioms) knowledge bases to provide deep, adaptive, expert decision support to battlefield commanders.
(U)	$6,922	Conduct research in physical mathematics and applied analysis and in electromagnetics to develop accurate models of physical phenomena to enhance the fidelity of simulations and predictability of devices. Investigate the properties of coherently propagating ultrashort laser pulses through the air and their exploitation in areas such as electronic warfare and laser-guided munitions. Develop algorithms to simulate nonlinear optical effects within semiconductor lasers and nonlinear optical media. Formulate optimal electromagnetic wave propagation/scattering codes to provide accurate and timely target recognition. Evaluate methods to penetrate tree cover with wide band radar to recognize and track targets. Study feasibility of designing reconfigurable warheads by suitable placement/timing of microdetonators. Pursue description of dynamics of internal stores released from transonic/supersonic platforms.
(U)	$4,897	Conduct research in optimization and discrete mathematics to validate and further advance mathematical methods for solving complex problems in logistics, engineering design, and strategic/tactical planning for battlespace information management. Evaluate anytime algorithms -- those that produce a feasible, but not necessarily optimal, solution. Examine new modeling techniques and computer algorithms for various urgent Air Force problems such as target tracking, mobilization planning, and manufacturing.
(U)	$4,560	Perform computational mathematics research to create unique simulations and designs of advanced Air Force systems. Devise means to integrate new multi-disciplinary design optimization strategies with high-order, time-accurate solvers in order to design superior jet engines, aircraft wings, munitions, and other aerospace components. Develop new algorithms for unsteady reactive flow, munition penetration and fragmentation, and plasmadynamics for directed energy weapons. Develop quantum computing algorithms, architectures, and implementations

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BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2304

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

to enable exponential improvements in speed, accuracy, and fidelity of fluid dynamics simulations, signal processing, and data mining.

(U) $2,872 Investigate signals communication and surveillance to expand the capability of critical mobile, networked communications, and surveillance/reconnaissance and targeting systems through examination of fundamental principles governing signal analysis. Areas of study include linear operator theory, generalized functions and probability, harmonic methods, and asymptotic expansions. Explore source-channel encoding methods for robust wireless communication using optical transmission phenomenology. Develop a rigorous basis for and delineate the domain of applicability of self learning, trial and error (heuristic) methods such as super-resolution imaging. Research technologies with higher information rates and higher reliability of communications.

(U) $32,211 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,603 Extend dynamics and control research to develop new techniques for design and analysis of control systems. Research findings will significantly enhance capabilities and performance of aerospace vehicles. Focus of the research is on cooperative control in dynamic, uncertain, adversarial environments with applications to swarms of smart munitions, unmanned aerial vehicles (UAVs), and constellations of small satellites. Develop control methodology to improve nonequilibrium behavior of complex, unsteady fluid systems (chemically reacting flows) with applications to combustion, materials processing and agile autonomous flight. Foster advances in image processing and sensors applicable to advanced controllers for UAVs, smart munitions, and non-destructive testing of aging or stealth aerospace vehicles. Design computational models to analyze biological processes for adaptation to air and space systems. Adapt explorations in bio-inspired sensing systems to assess feasibilty for and applicability in use in controlling autonomous systems.

(U) $6,437 Investigate complex systems and software, artificial intelligence, automatic knowledge acquisition, and high performance knowledge bases to allow rigorous construction of highly complex, secure battlefield information systems. Continue research in information assurance, including support for language-based security, mobile code security, protected execution, steganography/steganalysis and dynamic, adaptive intrusion detection for protection of future battlespace/infosphere systems and networks. Develop new computational techniques/software for information fusion at the situation refinement and impact assessment levels to provide deep, adaptive, expert decision support to battlefield commanders. Construct quantum computer devices that enable atomic level computing a million times faster than state-of-the-art silicon chip to allow enhanced target tracking, command and control, and decisive awareness. Design, implement, and test quantum computing algorithms and architectures enabling fast, accurate solutions of complex fluid dynamics problems eliminating the need for multiple design iterations and prototype testing. Continue developing scalable quantum computers for automatic target recognition and target characterization.

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BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2304

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$6,257	Conduct research in physical mathematics and applied analysis, and electromagnetics to develop accurate models of physical phenomena that enhance the fidelity of simulations and predictability of equipment. Investigate the properties of coherently propagating ultrashort laser pulses through the air and their exploitation in areas such as electronic warfare, laser-guided munitions, and irradiation of chemical/biological clouds. Develop algorithms to simulate nonlinear optical effects within fiber lasers and nonlinear optical media to exploit in future weapons. Formulate optimal electromagnetic wave propagation/scattering codes to provide accurate and timely target recognition. Evaluate methods to penetrate tree cover with wide band radar to recognize and track targets. Study feasibility of designing reconfigurable warheads by suitable placement/timing of microdetonators. Pursue description of dynamics of internal stores released from transonic/supersonic platforms.
(U)	$4,382	Enhance research in optimization and discrete mathematics to validate, advance, and exploit mathematical methods for solving complex problems in system diagnostics/prognostics, air mobility contingencies, and strategic/tactical planning for battlespace information management. Continue evaluating anytime algorithms -- those that produce a feasible, but not necessarily optimal, solution. Examine new modeling techniques and computer algorithms for various Air Force present and long-term challenges, such as target allocation for unmanned air vehicles, special operations planning, and system health and maintenance.
(U)	$3,442	Perform computational mathematics research to develop unique modeling and simulation capabilities for improving design methods for future Air Force systems. Integrate new multi-disciplinary design optimization strategies with high-order, time-accurate solvers for superior design of jet engines, aircraft wings, munitions, as well as other air and space components. Efficiently compute the simulation uncertainty in nonlinear models of aerodynamic flows and structural failure predictions. Develop new algorithms for unsteady reactive flow, munitions penetration and fragmentation, and plasmadynamics for directed energy weapons.
(U)	$2,504	Conduct investigations to expand the capability of critical mobile, networked communications through mathematical innovations in signal processing. Examine the fundamental principles of stochastics and probabilistic analysis to actuate proof-of-concept surveillance/reconnaissance and targeting systems. Employ linear operator theory, generalized functions, differential equations, and quantum theory to facilitate flexible, high bandwidth reliable transmission of multi-source data. Explore hybrid radio-frequency and optical phenomenology to achieve robust wireless communication. Delineate the domain of applicability of self-learning, and heuristic methods such as super-resolution imaging. Examine revolutionary technologies that attain ultra-fast information exchange with superior dependability.
(U)	$29,625	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602201F, Aerospace Flight Dynamics.

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0602500F, Multi-Disciplinary Space Technology.

(U) PE 0602602F, Conventional Munitions.

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

(U) PE 0603789F, C3I Advanced Development.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences / PROJECT: 2305

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2305	Electronics	26,809	23,918	23,856	25,280	27,001	29,383	29,793	30,183	Continuing	TBD

(U) A. Mission Description

Electronics basic research enhances the fundamental understanding of electronic materials, devices, and systems to advance Air Force operational capabilities in directed energy weapons, stealth technologies, electronic countermeasures, information and signal processing, and communications. Research seeks to develop fundamental technologies to meet future Air Force challenges in the areas of target search, command and control, and aerospace dominance. The research enables the development of electronic processes to model and predict the performance of electronic materials, devices, and systems for power generation, optical signal processing, radiation effects, and high-speed signal processing. The goals are to firmly control the complexity and reliability of electronic systems, increase data transmission and information processing speeds, and to improve the security and reliability of electronic information. The primary areas of research investigated by this project are space electronics, optoelectronic materials, optoelectronic information processing, optoelectronic memory technologies, and quantum electronic solids.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $7,789 Performed space electronics research to examine military unique low-power and complementary electronic circuits to greatly reduce the size and weight of space platforms. Studied the effects of intense radio frequency (RF) pulses on electronic circuits and systems. Continued to devise means to prevent surface and interface states from degrading electronic device performance. Further explored wide bandgap semiconductor materials as promising candidates for RF power sources and high-temperature operations. Expanded identification of fundamental radiation effects on electronic and semiconductor materials and devise methods to prevent space system degradation or destruction.

(U) $7,567 Conducted optoelectronic materials research for detection and emission of optical radiation from far infrared to the ultraviolet spectral range to achieve spectral dominance of the battlespace. Investigated new nonlinear optical materials to protect critical optical systems from laser fire, and access laser wavelengths and power not available with solid state or semiconductor lasers. Studied basic mechanisms that limit the efficiency and uncooled operation of lasers and detectors. Expanded formulation of laser materials to degrade or blind an adversary's detection and tracking capabilities. Investigated fast multiband detectors for characterization of the battlespace, surveillance, target tracking, and target signatures. Studied unique properties available from nanoscale combinations of optoelectronic materials.

(U) $4,487 Studied optoelectronic information processing to explore development and application of electro-optical materials and devices to enhance critical communication system accuracy, speed, and data storage. Investigated high bandwidth, multi-wavelength modulators and detectors to develop and refine complex semiconductor structures for imaging and communication systems. Created optical materials for maximum high-bandwidth communication and parallel signal processing. Investigated the use of new optical materials for enabling secure satellite communications and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2305

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

increased data transfer speeds required for military operations.

(U) $3,778 Performed quantum electronic solids research to investigate superconducting, magnetic, and nanoscopic materials and devices for advanced sensing communications and signal processing, and superior data storage capabilities. Improved high-temperature, high-current superconducting tapes and cables for enhanced storage and power generation on Air Force space platforms and directed energy weapons. Developed new techniques to quantify active corrosion in aircraft structures to increase lifespan. Investigated new high-temperature magnetic materials with sufficient mechanical strength for utilization in aircraft with higher electric workloads.

(U) $1,932 Conducted research addressing the scientific barriers to miniaturization of components enabling much lighter, more compact, highly capable micro- and nano-satellites. Performed researched into nanopropulsion and power schemes, smart skins, radiation hardening and quantum effect electronics to reduce satellite cost, weight, and size each by a factor of ten. Investigated nano-satellite benefits for improving access to space, mission flexibility, ease of augmentation and upgrade, and graceful degradation during end of service life.

(U) $1,256 Established focused ion beam research associated with system optimization and characterization. Investigate properties for establishing and regulating the narrowest beam diameter at relatively high energy. Probed the effects and benefits derived from a wide range of isotopes provided by various liquid metal ion sources. Researched means to enable advancing computing, sensing, and image processing associated with ion beam research.

(U) $26,809 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $8,485 Conduct research on military space platform unique electronic circuits aimed at greatly reducing component part count, size, and weight, while increasing performance and reliability. Expand study of intense radio frequency (RF) pulse effects on electronic circuits and systems. Design, fabricate, and evaluate wide bandgap semiconductor materials to achieve an unique combination of high RF power output, high efficiency, low noise, robustness, and radiation hardness. Conduct research on the interaction of systems and sensors with the space environment. Develop models to predict the effects of terrestrial and space backgrounds and radiation on sensor performance in order to promote secure, wide bandwidth communication through the atmosphere and ionosphere as well as between satellites. Initiate studies of reconfigurable electronics.

(U) $7,469 Research optoelectronic materials for detection and emission of optical radiation from the far infrared to ultraviolet spectral range to achieve spectral dominance of the battlespace. Investigate unique nonlinear optical materials to protect critical optical systems from laser radiation. Assess basic electronic mechanisms to improve the efficiency and reduce the cooling requirements of lasers and detectors. Synthesize laser materials to degrade or disable an adversary's detection and tracking capabilities. Create fast multiband detectors for characterization of the

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BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2305

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

battlespace, surveillance, target tracking, and target signatures. Develop nano-fabrication technology for unique optoelectronic material properties.

(U) $2,376 Conduct research in optoelectronic information processing to explore the design, development, and application of novel optoelectronic materials and devices to enhance critical communication system accuracy and speed. Examine complex semiconductor structures and develop optical materials for use in high bandwidth, multi-wavelength modulators and detectors for secure satellite imaging and faster data transfer rate communication systems. Explore optoelectronic nanotechnologies: nanophotonics, nanoelectronics, and nanosensors and opportunities in terahertz technologies.

(U) $4,001 Further investigate quantum electronic solids phenomena to explore superconducting, magnetic, and nanoscopic materials for advanced sensing, communications, and signal processing. Examine superconducting quantum systems for adaptation to quantum computing and encryption. Probe high-current, high-temperature superconducting cables and tapes for enhanced power generation and storage on Air Force directed energy weapons and space platforms. Develop new high-temperature magnetic materials with sufficient mechanical strength for use in aircraft with higher electric workloads.

(U) $1,587 Perform research in optoelectronic memory technologies and persistent spectral hole-burning systems for data storage and processing. Investigate page-oriented or holographic memory configurations in two- or three-dimensions. Explore capabilities to buffer, store, and retrieve data at rates and quantities anticipated for multi-spectral devices. Develop new technogies to increase capabilities in high-speed image capture, data storage, and information processing for surveillance, target discrimination, and autonomous navigation.

(U) $23,918 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $8,528 Expand research on military space platform unique electronic circuits aimed at greatly reducing component size and weight while increasing reliability. Research the scientific barriers to miniaturization of components enabling much lighter, more compact, highly capable microsatellites and nanosatellites. Explore nanopropulsion and power schemes, smart skins, radiation hardening, and quantum effect electronics to reduce satellite cost, weight, and size each by a factor of ten. Investigate nanosatellite benefits for improving access to space, battlefield awareness and control, mission flexibility, ease of augmentation and upgrade, and graceful degradation during end of service life. Further exploration of intense radio frequency (RF) pulse effects on electronic circuits and systems. Design, fabricate, and evaluate wide bandgap semiconductor materials to achieve a unique combination of high RF power output, high efficiency, low noise, robustness, and radiation hardness. Initiate efforts to identify electronic approaches to increasing spacecraft survivability. Enhance research into the fundamental interaction of systems and sensors with the

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BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2305

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

space environment. Develop models to predict the effects of terrestrial and space backdrops and radiation on sensor performance in order to promote secure, wide bandwidth communication through the atmosphere and ionosphere as well as between satellites to ensure superior strategic awareness.

(U) $7,683 Further research into optoelectronic materials for detection and emission of optical radiation from the far infrared to ultraviolet spectral range to achieve spectral dominance of the battlespace. Investigate unique nonlinear optical materials to protect critical optical systems from laser radiation. Assess basic electronic mechanisms to improve the efficiency and reduce the cooling requirements of lasers and detectors. Synthesize laser materials to degrade or disable an adversary's detection and tracking capabilities. Create fast multiband detectors for characterization of the battlespace, surveillance, target tracking, and target signature identification. Develop nano-fabrication technology for unique optoelectronic materials. Probe new materials for high efficiency photovoltaic devices.

(U) $2,281 Research optoelectronic information processing and relevant nano science to explore the design, development, and application of novel optoelectronic materials and devices in order to enhance the accuracy and speed of critical communications. Exploit guided wave and wireless communications networks with dense arrays for potential application to intelligent sensors, compact reconnaissance platforms, and revolutionary unmanned and manned Air Force assets. Initiate exploration of ultracompact microphotonic and nanophotonic structures and chip scale optical networks, with design and engineering of the electromagnetic properties of materials at the scales comparable to the wavelength of light. Investigate quantum computing device approaches for advanced computing and signal processing. Expand the science and technologies of the terahertz frequency spectrum through robust monolithic and miniature devices for security, remote sensing, optical communications, and optical signal processing.

(U) $1,522 Examine optoelectronic memory and persistent spectral hole-burning approaches for enhanced data storage and processing to enable superior strategic awareness. Evaluate methods for constructing page-oriented or holographic memory configurations in two or three dimensions. Research methods of buffering, storing, and retrieving data at rates and quantities anticipated for multi-spectral devices. Evaluate techniques for enhancing capabilities in high-speed image capture, data storage, and information processing for surveillance, target discrimination, and autonomous navigation.

(U) $3,842 Expand investigations into superconducting, magnetic, and nanoscopic materials for advanced sensing, communications, and signal processing. Examine superconducting quantum systems for adaptation to quantum computing and encryption. Probe high-current, high-temperature superconducting cables and tapes for enhanced power generation and storage on Air Force directed energy weapons and space platforms. Further the development of new high-temperature magnetic materials with sufficient mechanical strength for use in aircraft with higher electric workloads.

(U) $23,856 Total

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PROJECT: 2305	

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602204F, Aerospace Sensors.

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

(U) PE 0603203F, Advanced Aerospace Sensors.

(U) PE 0603789F, C3I Advanced Development.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)			DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences		PROJECT: 2306

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2306 Materials	15,946	14,608	15,164	17,598	19,223	21,457	20,771	20,079	Continuing	TBD

(U) A. Mission Description

Materials research enables the development and implementation of structural materials that provide reliable performance in applications related to high-temperature strength, toughness, fatigue, and environmental conditions. The goal is to provide fundamental knowledge to make possible future systems that provide rapid global reach, on demand space surge, and measured global force projection. The 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 materials for air and space vehicles that provide increased structural efficiency and reliability, increase the operating temperature of engine materials, and further increase thrust-to-weight ratio of engines. Basic research emphasis is on refractory alloys, intermetallics, shape memory alloys, polymer composites, metal and ceramic matrix composites, advanced ceramics, such as alumina, silicon carbide, silicon nitride, and carbon/carbon, and new material processing methods. The primary areas investigated by this project are ceramic and non-metallic materials, metallic materials, and organic matrix composites

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,624 Performed ceramic and non-metallic materials research to understand optimum strength of very high temperature, non-metallic materials for airbreathing and rocket engines, and space vehicle applications. Studied thermal and mechanical stability interaction of very-high temperature oxide and non-oxide composites for jet engine blade applications. Advanced fundamental materials knowledge to develop ultra-high temperature material systems based on carbides for rocket propulsion applications.

(U) $7,286 Conducted metallic materials research to develop affordable and durable metallic systems for advanced engines and aerospace structural applications. Investigations focused on mechanical and thermal stability of composites, metal refractory alloys, and intermetallics for very-high temperature aircraft applications. Developed functionally gradient structures for superior thermal barrier coatings. Created advanced metals for multi-functional space systems.

(U) $2,103 Performed organic matrix composites research to advance polymer matrix composite knowledge and increase the life-span and strength of aerospace structures. Studied thermal cycling effects of polymer matrix composites at cryogenic temperatures to improve material durability in liquid fuel tank environments. Researched novel fiber sizing techniques to minimize moisture degradation of mechanical and electromagnetic properties in glass fiber reinforced composite structures.

(U) $1,933 Developed new mathematical and computational strategies to reduce maturity time for new materials by ~50% and to minimize the costs of new structural materials for aerospace systems. Explored scientific basis for computational design to reduce amount of costly experimentation

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	PROJECT 2306

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

required. Developed high performance materials more affordably through synchronization of material development and engineering system design.

(U) $15,946 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $5,042 Perform ceramic materials research to develop new materials and composites for use at very high temperature and/or hostile environments. Investigation of the optimization of thermal and mechanical stability of oxide composites for aircraft and jet engine blade applications. Create ultra-high temperature materials systems based on non-oxide materials for space applications. Design and optimize multi-functional materials to enable the combination of structural and functional ceramics to enable enhanced fuel cells, sensors and actuators.

(U) $7,275 Continue metallic materials research to develop affordable and durable metallic systems for advanced engines and aerospace structural applications. Investigations focus on the integration of computational materials science and materials design into the design of engineering components, mechanical and thermal stability of metal matrix composites, development and characterization of refractory metal alloys and intermetallics for very-high temperature aircraft applications. Develop functionally graded structures for superior thermal barrier coatings. Create advanced metals for multi-functional space systems.

(U) $2,291 Perform organic matrix composites research to advance polymer matrix composites knowledge to increase the strength and life span of aerospace structural materials. Analyze effects of cyclic thermal loads on polymer matrix composites down to cryogenic temperatures to increase durability in liquid fuel tank materials. Develop new fiber sizing techniques in glass fiber reinforced structures to minimize degradation of mechanical and electromagnetic properties due to moisture.

(U) $14,608 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,992 Explore ceramic and non-metallic materials research to design new materials and composites for future global reach and space access operations requiring very high temperature, hostile environments use materials. Expand studies optimizing the thermal and mechanical stability of oxide composites for aircraft and jet engine blade applications. Extend research on ultra-high temperature ceramic materials for space propulsion and structural systems. Maintain research focus on the design and optimization of multi-functional ceramic materials to enable structurally enhanced smart systems.

(U) $7,902 Probe metallic materials integrating computational models of material behavior into engineering design applications to exploit advanced engines

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BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences	PROJECT 2306

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

as well as air and space structural applications. Expand experimental and modeling studies of mechanical strength, thermal stability, performance prediction, and lifetime assessment of composites, refractory metal alloys, and intermetallics for applications at moderate and very high temperatures. Develop advanced alloys for multi-functional space systems. Develop new mathematical and computational strategies to reduce maturity time for new materials by ~50% and to minimize the costs of new structural materials for air and space systems. Explore scientific bases for computational design to reduce the amount of costly experimentation required to develop new materials. Seek to develop high performance materials more affordably by integrating material development and engineering system design.

(U) $2,270 Investigate organic matrix composites to advance polymer matrix composites knowledge in order to increase the strength and life span of air and space structural materials. Analyze the effects of cyclic thermal loads down to cryogenic temperatures on polymer matrix composites in order to increase durability in liquid fuel tank materials. Develop new fiber sizing techniques in glass fiber reinforced structures to minimize the degradation of mechanical and electromagnetic properties due to moisture.

(U) $15,164 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602102F, Materials.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0603211F, Aerospace Structures.
(U) PE 0708011F, Industrial Preparedness.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)

DATE: February 2003

BUDGET ACTIVITY: 01 - Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT: 2307

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2307 Fluid Mechanics	9,705	10,320	10,985	11,901	12,024	12,241	12,437	12,623	Continuing	TBD

(U) A. Mission Description

Fluid Mechanics research advances fundamental knowledge, tools, data, concepts, and methods for improving the efficiency, effectiveness, and reliability of air and space vehicles that will provide rapid global reach and revolutionize access to space. The goals are to improve theoretical models for aerodynamic prediction and design as well as to originate flow control concepts and predictive methods used to expand current flight performance boundaries through enhanced understanding of key fluid flow; primarily high-speed air phenomena. Basic research emphasis is on turbulence prediction and control, unsteady and separated flows, super- and subsonic flows, and internal fluid dynamics. The primary approach is to formulate advanced computational methods to: simulate and study complex flows; predict real gas effects in high-speed flight; and control and predict turbulence in flight vehicles and propulsion systems. Primary areas of research investigated by this project are unsteady aerodynamics, hypersonic aerodynamics, turbulence and flow control, and rotating flows.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,427 Performed unsteady aerodynamics research to provide fundamental knowledge of high-speed airflows to optimize future Air Force air vehicle designs and enable revolutionary future weapon systems. Investigated unsteady, complex, three-dimensional flows to refine the control and flight performance of unmanned air vehicles. Completed the development of design tools for flow control to minimize flow separation and air vehicle drag. Completed the development of fluid/structural interaction design tools to predict vehicle failure modes in rapid maneuvers.

(U) $2,912 Conducted hypersonic aerodynamics research to investigate complex flowfield phenomena for enabling the design of future Air Force trans-atmospheric vehicles and their flight control systems. Researched advanced concepts for hypersonic flow control such as plasma or magneto-hydrodynamic techniques. Developed high-speed flow prediction codes to quantify thermal stresses. Investigated high temperature mitigation techniques for hypersonic flight vehicles.

(U) $2,424 Sought fundamental knowledge of turbulence in coordinated experimental and computational simulation efforts. Investigated flow control concepts to enhance the performance, controllability, and stability in air vehicles. Developed new predictive tools for the air vehicle design process. Evaluated promising flow control actuation concepts and investigate flow control coupling mechanisms in turbulent flows to enable agile flight vehicles with significantly reduced power requirements.

(U) $1,942 Studied complex rotating flow phenomena as they relate to turbomachinery and jet engine applications. Evaluated unsteady flow phenomena for enhancing the performance and reliability/maintainability of airbreathing propulsion systems. Continued development of Large Eddy Simulation methodology for affordable high fidelity predictions of gas turbine engine flow fields and heat transfer effects. Developed understanding of high

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

cycle fatigue aerodynamic forcing. Evaluated possible flow control applications in turbine engines.

(U) $9,705 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,595 Perform unsteady aerodynamics research to provide fundamental knowledge of high-speed airflows to optimize current Air Force air vehicle designs and enable revolutionary future weapon systems. Investigate unsteady, complex, three-dimensional flows to refine the control and flight performance of unmanned aerial vehicles (UAVs). Investigate rapid maneuver UAV aerodynamics. Investigate highly separated flow situations occurring in complex air vehicle and weapon systems.

(U) $3,073 Investigate complex phenomena in hypersonic flows to enable the design of future Air Force trans-atmospheric vehicles and flight control systems. Complete development of supersonic flow control concepts, including plasma and magneto-hydrodynamic techniques. Develop high-speed flow prediction codes to quantify thermal stresses and design mitigation techniques for hypersonic flight vehicles.

(U) $2,595 Explore fundamental knowledge of turbulence in coordinated experimental and computational simulation efforts. Investigate new areas and methods of flow control on aircraft wings and jet engines to enhance the performance, controllability, and stability in air vehicles. Develop reduced order models for turbulent flow control applications and affordable engineering predictive models for the air vehicle design process. Assess quality of promising flow control actuation concepts on realistic geometries. Continue investigating flow control coupling mechanisms in turbulent flows to enable agile flight vehicles.

(U) $2,057 Study complex rotating flow phenomena as they relate to turbomachinery and jet engine applications. Evaluate unsteady flow phenomena and develop understanding of forcing modes in turbomachinery to predict and avoid high cycle and thermal failures in jet engines. Investigate application of Large Eddy Simulation techniques to explore complex gas turbine engine flow fields and heat transfer effects. Evaluate flow control measurement and actuation devices for use in harsh environments such as turbine engines.

(U) $10,320 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,760 Characterize the critical phenomena in unsteady aerodynamic flows to allow optimization of current Air Force air vehicle designs that will make possible revolutionary future weapon systems. Develop the numerical tools and validating experimental database to determine the effect of unsteady, vortex-dominated flows on the control and flight performance of unmanned aerial vehicles (UAVs). Investigate aero/structure interactions associated with rapid maneuver UAVs. Develop tools for the accurate prediction of highly separated flow structure occurring in

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(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

flow over complex air vehicle and weapon systems.

(U)	$3,256	Characterize critical aerothermal phenomena in super- and subsonic flows to enable the design of potential Air Force trans-atmospheric vehicles and flight control systems. Examine advanced flow control concepts for shock-dominated flows. Pursue aerothermal numerical simulation capabilities to quantify heat transfer and unsteadiness for flight vehicles.
(U)	$2,760	Utilize experimental and computational simulations to develop more robust turbulence modeling approaches for complex flow phenomena. Develop approaches for modeling unsteady flow control inputs on aircraft wings and jet engines to enhance the performance, controllability, and stability in air vehicles. Utilize reduced order models for turbulent flow control applications and affordable engineering predictive models for the air vehicle design process. Test promising flow control actuation concepts on realistic geometries in wind tunnel tests. Continue investigating flow control coupling mechanisms in turbulent flows to enable agile flight vehicles.
(U)	$2,209	Study complex rotating flow phenomena as they relate to turbomachinery and jet engine applications. Explore coupling mechanisms in multiple blade row interactions in order to develop understanding of forcing modes in turbomachinery and to predict high cycle fatigue failures in jet engines. Utilize Large Eddy Simulation techniques to explore heat transfer and fluid flow coupling in turbine engine flow fields. Develop flow control measurement and actuation devices for use in harsh environments such as turbine engines.
(U)	$10,985	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602102F, Materials.

(U) PE 0602201F, Aerospace Flight Dynamics.

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0603211F, Aerospace Structures.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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PROJECT: 2308

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2308 Propulsion	22,060	23,216	13,245	13,774	21,851	22,208	22,563	22,903	Continuing	TBD

Note: Funding in FY 2004 and 2005 decreased due to decreased emphasis in hypersonics basic research.

(U) A. Mission Description

Propulsion 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, and thermal management of space-based power and propulsion systems. Two key basic research areas include reacting flows and non-chemical energetics. Study of chemically 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 plasma and beamed energy propulsion for orbit raising space missions, and efficient ultra-high energy techniques for space-based energy utilization. Primary areas of research investigated by this project are space power, propulsion, combustion, and diagnostics.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,934 Performed space power and propulsion research to investigate novel propulsion mechanisms to enable superior satellite propulsion performance. Undertook studies to enable clusters of cooperating autonomous micro-satellites by improving thrust and control of micro- and nano-satellite propulsion systems. Researched mechanical-electric energy conversion and self-consuming satellites to increase payload and thrust. Explored supercritical combustion for optimal rocket propulsion using hybrid rockets and/or combined cycle engines. Performed research on digital propulsion and pulsed detonation rocket engines. Investigated opportunities to exploit experimental university satellites to measure thrust and cross-contamination in micro-satellite constellations. Developed novel space diagnostic techniques and 100 gram class sensors for accurate measurements on micro- and nano-satellites.

(U) $6,604 Studied combustion to evaluate airbreathing propulsion systems for hypersonic, supersonic, and subsonic flight to enhance air warfare capabilities. Increased combustion efficiency and reduce fuel consumption through enhanced computer models that can predict unsteady behavior such as combustion instability. Advanced the state of turbulent combustion simulation methods by incorporating refined models for chemistry and fuel droplets. Investigated enhancements to ignition and flame stabilization by weakly ionized flows.

(U) $4,268 Investigated advanced diagnostics systems for data reduction and interpretation to create concepts for novel propulsion system applications. Applied picosecond spectroscopic techniques to characterize turbulent combustion statistical behavior and supercritical fuel properties.

(U) $1,891 Researched methods for improving aerodynamics for next generation aerospace vehicles for long-range strike. Expanded research to develop

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

sound scientific basis for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies enabling hypersonic vehicles by reducing drag and improving range by more than 10%. Performed demonstrations to prove plasma control effects and to determine how to engineer them into operational systems. Investigated plasma effects on lowering fuel consumption, improving propulsion system performance, providing on-board power generation, and alleviating sonic boom and engine noise.

(U) $2,363 Continued research in coal-derived jet fuels to investigate refinery-processing techniques for coal processing with petroleum, additives to suppress fuel system fouling, combustion characteristics of candidate fuels, and fuel-material interactions. Sought to produce small quantities (50 gallons) of coal-derived fuel for large-scale combustion, fuel system fouling, and ignition experiments. Investigated potential for coal-derived fuel production scale-up.

(U) $22,060 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $7,222 Explore space power and propulsion research to investigate novel propulsion mechanisms to enable superior satellite propulsion performance. Study means to improve thrust and control of propulsion systems to develop high-precision constellations of cooperating micro-satellites. Expand understanding of mechanical-electric energy conversion to increase payload and thrust. Study feasibility of excess silicon as a space propellant in developing concepts for self-consuming satellites. Continue researching new engine concepts such as pulsed detonation engines, hybrid rockets, and combined cycle engines. Create advanced supercritical combustion models and leverage computational capability to enhance the design of new engines. Research plasma turbulence and its effect on the transport coefficients to develop a new class of more versatile plasma thrusters.

(U) $6,933 Study combustion to evaluate airbreathing propulsion systems for hypersonic, supersonic, and subsonic flight to enhance air warfare capabilities. Develop enhanced computer models that predict unsteady behavior, such as combustion instability, to increase combustion efficiency and reduce fuel consumption. Advance the state of Large Eddy Simulation methods for turbulent combustion by incorporating upgraded subgrid-scale models for chemistry and fuel droplets.

(U) $4,491 Complete studies of advanced diagnostics systems for data reduction and interpretation to create concepts for novel propulsion system applications. Complete study of laser-induced fluorescence and absorption spectroscopic measurements in relation to infrared and ultraviolet excitation wavelength regimes.

(U) $2,022 Study methods for enabling and improving aerodynamics for next generation aerospace vehicles for long range strike. Further expand research studies to develop sound scientific basis for how plasmas are used to improve aerodynamic characteristics and propulsive efficiencies enabling

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

hypersonic vehicles by reducing drag and improving range by more than 10%. Demonstrate plasma control effects and evaluate means to engineer them into operational systems. Investigate plasma effects on lowering fuel consumption, improving propulsion system performance, providing on-board power generation, and alleviating sonic boom and engine noise.

(U) $2,548 Enhance research in coal-derived jet fuels to investigate refinery-processing techniques for coal processing with petroleum, additives to suppress fuel system fouling, combustion characteristics of candidate fuels, and fuel-material interactions. Produce limited quantities (50 gallons) of coal-derived fuel for large-scale combustion, fuel system fouling, and ignition experiments. Further investigations for coal-derived fuel production scale-up.

(U) $23,216 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,813 Study micro-chemical, plasma-based, and beamed-energy based thrusters to improve thrust, specific impulse, and control of propulsion systems for high-precision constellations of cooperating micro-satellites in order to enhance decisive awareness of threats and opportunities. Further research into new engine concepts such as pulsed detonation engines, hybrid rockets, and combined cycle engines. Create advanced supercritical combustion models and leverage computational capabilities that will enhance the design of new hydrocarbon, cryogenic, and monopropellant-fueled engines. Conduct research plasma turbulence and its effect on the transport coefficients in order to develop a new class of more versatile plasma thrusters. Examine magnetohydrodynamic (MHD) flow control to optimize propulsion system flow path performance in scramjets. Investigate lightweight super conducting magnet capability for onboard flight-rated systems needed to achieve MHD flow control of advanced engines. Investigate plasma ignition approaches to improve combustion efficiency and stability in scramjets and high altitude subsonic airbreathing propulsion systemz. Research high altitude signature characterization and spacecraft cross-contamination, especially in the presence of multiple thrusters and satellites.

(U) $6,432 Study combustion in airbreathing propulsion systems for supersonic and subsonic flight to enable new concepts and capabilities to deliver and sustain our in-theater forces. Develop detailed mechanisms for hydrocarbon fuel combustion at elevated pressures. Improve laser diagnostic measurement capabilities with expanded agility over limited wavelength ranges for time-resolved characterization of reacting flows.

(U) $13,245 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602102F, Materials.

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0602500F, Multi-Disciplinary Space Technology.

(U) PE 0602601F, Space Technology.

(U) PE 0603211F, Aerospace Structures.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences — PROJECT: 2311

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2311	Space Sciences	16,293	15,123	15,654	16,268	16,446	19,670	17,984	18,235	Continuing	TBD

(U) A. Mission Description

Space Sciences research provides fundamental understanding of the space environment for optimum design of Air Force systems operating in near-Earth orbit, geosynchronous orbit, and deep space. The goal is to enable greater, more cost-affordable, protection of space assets from space debris, solar wind, solar flares, cosmic rays, and geomagnetic storms. Basic research focuses on specifying the flow of mass, momentum, and energy through space to develop a global model that connects solar activity with the deposition of energy at the Earth. The objective is to develop methods to forecast the turbulent plasma phenomena that mediate the flow of energy through space in order to enhance the effectiveness of Air Force global dominance through space operations. The primary areas of research investigated by this project are solar physics and astrophysical observation techniques, solar wind transport and magnetospheric physics, ionospheric physics and scintillation, energization processes in the Earth's radiation belts, and innovative science for space-based communications.

(U) FY 2002 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,652	Analyzed, characterized, and modeled solar phenomena for much better prediction of large-scale solar disruptions in the space environment, and to advance development of protective spacecraft structures and defensive operational techniques. Began obtaining high-resolution observations of solar plasma arcades, solar flares, and coronal mass ejections to establish the physical basis for solar disturbance models. Continued investigating sunspots, solar oscillation modes, and solar magnetic field spin states to enable forecasting of solar eruptions and predict environmental risks to critical Air Force space operations. Developed solar vector magnetographs using adaptive optics.
(U)	$3,636	Studied solar wind effects on the Earth's magnetospheric and radiation belt energization processes and morphology. Enhanced space systems performance degradation models. Developed models that provide realistic coupling of the magnetosphere - ionosphere system. Conceived magnetohydrodynamic models to develop a theoretical understanding of magnetic reconnection and self-organized criticality in the magnetosphere.
(U)	$4,367	Probed ionospheric scintillation and turbulence to enhance global surveillance, geolocation, and communication. Observed atmospheric gravity wave interactions from high-latitude and tropical observation sites using light detection and ranging techniques. Conducted airglow and auroral emission observations and characterize the chemical and physical dynamics of the mesosphere, thermosphere, and ionosphere to develop comprehensive seasonal and climatic maps of high-altitude phenomena.
(U)	$2,910	Characterized the populations of space debris particles derived from comets and asteroids to predict threats to Air Force spacecraft. Provided a test bed for advanced deep space surveillance techniques through new astronomical instrumentation and observational methods. Expanded laser

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

guide-star development and observations of space backgrounds and optical signatures of orbital targets over the tropics. Researched the variable energy deposited in near-Earth space by cosmic rays and energetic particles from deep space to identify risks to Air Force systems.

(U) $741 Researched space weather phenomena through the investigation of several solar variables observed from thousands of sun-like stars. Explored models detailing the evolution of our sun. Research supported through the Center for Solar Geophysical Interactions at the Mt. Wilson Observatory.

(U) $987 Supported basic research and educational outreach projects at the California Science Center to assure the Air Force access to superior scientific and engineering talent in future years. Efforts included research to increase the fundamental understanding of atmospheric conditions, weather phenomena, and expanded into biological sensory systems.

(U) $16,293 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,824 Observe and analyze solar phenomena to characterize and model the physics of solar magnetic fields for enhanced prediction of large-scale, high-energy plasma ejections in the space environment, to develop protective spacecraft structures and more robust designs. Explore technology requirements to enable development of a new ground-based Advanced Technology Solar Telescope to exploit adaptive optics techniques in solar observations. Continue investigating solar dynamo physics, solar oscillation modes, solar flares, coronal mass ejections, magnetic reconnection in space plasmas, and solar magnetic field complexity to enable forecasting of solar eruptions and predict environmental risks to critical Air Force space operations.

(U) $3,824 Develop mitigation techniques for ionospheric scintillation and plasma turbulence radio disruptions to enhance global surveillance, geolocation, and communication. Support scientific analysis of space-based and ground-based data assimilation techniques to modernize ionospheric and space weather forecasting. Continue to observe atmospheric gravity wave interactions from high and low geomagnetic latitudes, as well as tropical observation sites, using radars, advanced electro-optical instrumentation, and light detection and ranging techniques in order to develop seasonal and climatic models of ionospheric phenomena.

(U) $4,327 Predict threats to Air Force space assets by cataloging and tracking the populations of Near Earth Objects (NEOs) and space debris particles derived from comets and asteroids. Develop advanced astronomical instrumentation and observational methods to include laser ranging and adaptive optics for deep space surveillance. Explore laser guide-star development for observations of NEOs as well as ballistic and orbital targets. Exploit developments in astronomical detection and tracking algorithms for enhancement of DoD surveillance capability, and support observational campaigns to characterize the aerodynamic drag, turbulence, and optical clutter in the lower ionosphere that degrade DoD

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

targeting.

(U)	$3,148	Provide theoretical development, physics-based modeling, and space observation support to the Air Force's Communications/Navigation Outage Forecast System and Solar Mass Ejection Imager satellite missions. Investigate the theoretical underpinnings of robust antenna designs for the space environment and charged particle remediation techniques. Investigate the variable energy deposited in near-Earth space by energetic charged particles from deep space and by cosmic rays to quantify risks to Air Force systems.
(U)	$15,123	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,928	Exploit solar physics models to develop techniques for protecting Air Force assets against high-energy plasma ejections in the space environment. Investigate impacts of terrestial events, e.g., seismic activities. Support cutting-edge instrumentation development for the ground-based Advanced Technology Solar Telescope. Continue to investigate solar flares, coronal mass ejections, magnetic reconnection in space plasmas, and solar magnetic field complexity through support of ground-based optical and radio solar observatories, as well as university and government teams managing space-based instruments. Define best-practices and commonality of algorithms used to model and simulate the space environment, focused on plug-and-play capability within next-generation computational architectures.
(U)	$2,928	Expand deployment of research sensors to observe ionospheric scintillation and worldwide plasma turbulence radio disruptions. Support scientific analysis of space-based and ground-based data assimilation techniques to modernize ionospheric and space weather forecasting. Design and examine observational equipment globally to improve capability to observe atmospheric gravity wave interactions with radars, and advance electro-optical instrumentation, and light detection and ranging techniques. Exploit cutting-edge developments in all-sky imaging optics to obtain sensitive infrared observations of ionospheric plasma physics, gravity waves, dynamics, and optical clutter.
(U)	$3,709	Develop advanced multi-conjugate adaptive optics for unparalleled resolution of small, dim, deep-space targets. Continue to characterize threats to Air Force space assets by cataloging and tracking the populations of Near Space Objects and space debris particles derived from comets and asteroids. Exploit developments in astronomical detection and tracking algorithms to enhance Air Force space awareness and control capabilities. Expand development of future space radar surveillance systems using nanotechnology and advanced signal processing algorithms.
(U)	$2,254	Continue to investigate the theoretical underpinnings of active and passive space environment remediation techniques. Exploit data from the Air Force's Communications/Navigation Outage Forecasting System and Solar Mass Ejection Imager satellite missions to create new space environment models and enhance current theories. Stimulate novel efforts to advance design, study, and development new sensor technologies to observe cosmic rays and energetic charged particles from deep space in order to better quantify risks to Air Force space systems. Research

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(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

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

(U) $3,835 Investigate innovative technologies for space-based communication capabilities to ensure continued Air Force space dominance. Research innovative methods for optical communications. Probe novel techniques for potential bandwidth efficient modulation to enhance satellite communications. Explore the basic mechanisms of dual polarization antennas for space applications.

(U) $15,654 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0602702F, Command, Control, and Communications.
(U) PE 0603410F, Space System Environmental Interactions Technology.
(U) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2312 Biological Sciences	13,535	14,005	14,352	14,720	14,879	18,072	15,389	15,621	Continuing	TBD

(U) A. Mission Description

Biological Science research provides the fundamental knowledge necessary to understand and enable technologies associated with chemical and physical agent toxicity, electromagnetic sensors based on biomimicry, biomolecular materials, biochromatics, and luminescence, as well as neuroscience and chronobiology. The goal is to exploit biological properties to control and manipulate operational environments. Research topics in toxicology explore the interaction of Air Force chemicals and physical agents (lasers and microwaves) with human tissues and associated effects to enable safety assessment strategies to ensure the hazard-free development and use of future aerospace materials and directed energy systems. Research in biomimetic sensors strives to mimic the biological detection systems of organisms at the molecular level in developing novel man-made sensors. Basic research in biocatalysis characterizes cellular enzymes that will catalyze the synthesis of chemical feedstocks used in the safe production of space and air materials. Research in neuroscience and chronobiology provides new strategies to maintain decisive awareness by preventing impaired operational performance due to jet lag and shift-work, night operations, and the loss of life and/or aircraft due to stress, inattention, or lack of vigilance. The primary areas of research investigated by this project are bioenvironmental sciences, biocatalysis, chronobiology and neural adaptation, and biomimetic sensors.

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,632 Studied bioenvironmental sciences to investigate the biological effects of exposure to military aerospace chemicals and directed energy systems used by the military to assure the safety, health, and high performance of personnel before, during, and after mission-directed activities. Explored the molecular and cellular effects of JP-8 jet fuel on the lung, brain, skin, and immune system and continue to identify specific molecular pathways involved in eliciting and blocking toxic responses. Continued to develop reliable in vitro simulators of in vivo toxic responses and learn to use them to rapidly acquire and predict toxic profiles at a sub-cellular level. Continued to identify and quantify subtle, gene-induced effects of directed energy (microwaves and lasers) on cellular targets and determine the approximate exposure levels at which these effects are significant.

(U) $3,385 Researched biocatalysis to discover and characterize enzymes from living cells for use as biocatalysts to reduce cost, increase efficiency, and assure safety in chemical feedstocks synthesis for aerospace materials. Discovered, isolated, cloned, and sequenced genes of novel enzymes of use to the military. Biochemically characterized the enzymes and investigate their mechanisms of reaction, kinetics, substrate range, and specificity.

(U) $1,893 Performed chronobiology and neural adaptation research to examine the biological mechanisms responsible for crew fatigue, adaptation to the

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

environment, and individual performance capabilities to improve skilled human performance. Continued to analyze the mechanism by which serotonin regulates the circadian clock. Research the effect of modafinil on preventing adverse performance effects without disrupting sleep. Further optimization of the combination of fatigue countermeasures such as optimally-timed rest periods and alertness promoting compounds.

(U) $1,625 Conducted biomimetic research to enable the development of novel sensors, engineering processes, and mechanisms. Investigated fundamental biological properties and processes of infrared sensitive biosystems at the cellular, sub-cellular, and molecular levels to enable the development of novel infrared materials and devices with enhanced structural and functional capabilities. Identified, isolated, and modeled alternate mechanisms of near ambient infrared sensing in biosystems to enable and/or enhance compact, room-temperature infrared sensors. Probed the functionality of alternative sensors for time-response characteristics. Investigated biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for application to military sensors.

(U) $13,535 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,536 Study bioenvironmental sciences to investigate the biological effects produced by exposure to air and space chemicals and directed energy systems used by the military to assure the safety, health, and high performance of the warfighter before, during, and after mission-directed activities. Continue to identify organ-specific molecular pathways altered by JP-8 jet fuel exposures and evaluate various biomolecular indicators and mediators of the toxic response for use as potential biomarkers of human exposure and to enable the development of protective strategies. Explore mechanisms and develop novel molecular descriptors that will help integrate in vitro toxicity data into a mathematical format for use in the rapid computational prediction of toxicity of air and space chemicals and new forms of directed energies. Investigate the biological effects of chronic low level exposures to directed energy by profiling and modeling intracellular molecular responses and identifying potentially harmful extra-cellular mediators.

(U) $3,661 Research biocatalysis to discover and characterize enzymes from living cells that can be used as biocatalysts to reduce cost, increase efficiency, and assure safety in the process of synthesizing chemical feedstocks used in the manufacture of aerospace materials. Continue the essential and fundamental process of enzyme discovery and characterization. Genetically modify the natural biocatalytic potential of enzymes to meet various synthetic manufacturing requirements by extending substrate ranges and specificities or altering reaction rates. Explore alternative metabolic engineering techniques for maintaining or enhancing reaction rates during large-scale production.

(U) $2,051 Investigate the biophysical mechanisms responsible for crew fatigue in sustained operations or in non-standard duty cycles and in adapting to jet lag. Test mathematical models of sleep/wake dynamics, including the effects of wake-promoting countermeasures on the homeostatic and

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

circadian systems, and extend these models to predict specific deficits in human performance under conditions of sleep loss. Begin new research to identify the phenotypic differences that enable some individuals to maintain highly accurate cognitive and psychmotor performance under sleep deprivation.

(U) $1,757 Continue to conduct biomimetic research to enable the development of novel sensors, engineering processes, and mechanisms. Model the fundamental principles, processes, and designs of infrared sensitive biosystems at the sub-cellular, molecular and genomic levels to enable the further development of infrared materials, devices, and systems with enhanced structural and functional capabilities. Identify, model, and construct alternative biomimetic, near ambient infrared sensing devices. Probe and manipulate the functionality of alternative sensors for time-response characteristics. Adapt biochromophores and biophotoluminescent characteristics in microbial and protein-based biosystems for applications to military sensor systems.

(U) $14,005 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $6,992 Investigate the biological effects produced by exposure to air and space chemicals and directed energy systems used by the military to assure the safety, health, and high performance of the warfighter before, during, and after mission-directed activities. Initiate a biokinetics study of the uptake, biodistribution, metabolism, and elimination of JP-8 fuel in animals exposed through the inhalation and skin routes as a first step in assessing the human health risks of jet fuels. Extend research on molecular descriptors and mathematical expression of in vitro toxicity data to include data from genomics and proteomics profiles to rapidly predict computationally the toxicity of air and space chemicals. Extend sensitive genomics and proteomics profiling techniques to studies investigating the cellular and extra cellular effects of chronic and acute low-level exposures of animals to laser and microwave systems.

(U) $3,607 Research biocatalysis to characterize and modify enzymes from living cells to use as biocatalysts in the process of synthesizing chemical feedstocks used in the manufacture of air and space materials to reduce cost, increase efficiency, and assure safety. Improve reaction rates and specificity of microbial oxygen-based enzymes to economically biosynthesize normally expensive reactants needed to manufacture of polymeric air and space materials. Begin developing approaches to identify unique bioenergetic enzymatic components from photosynthetic and/or microbial reaction pathways that may facilitate the development of novel biofuel cells to ensure future space access and continued operations. Further explore alternative metabolic techniques for maintaining or enhancing reaction rates during large-scale production either in the presence or absence of non-aqueous solvents.

(U) $2,021 Research the biophysical and neural mechanisms that determine human cognitive performance under conditions of sleep loss, sustained

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(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

operations, and non-standard sleep/wake duty cycles to ensure effective air and space persistence. Refine mathematical models of the interaction of homeostatic and circadian mechanisms to account for, and predict the effects of wake-promoting countermeasures on human performance. Develop science-based estimates for the use of caffeine, modafinil, light exposure, and naps. Continue to study genetic differences that make some individuals highly resistant, and others highly susceptible to sleep loss to develop future operational flexibility and persistence.

(U) $1,732 Enhance biomimetic research to enable developing novel sensors, engineering processes, and mechanisms for improved Air Force operations. Continue studying biomaterials and biointerfacial sciences to synthesize novel materials, prepare new biosensors, and exploit bionanotechnology. Model the fundamental principles, processes, and designs of noncryogenic infrared sensitive biosystems at the sub-cellular, molecular and genomic levels to enable the future infrared materials, devices, and systems with enhanced structural and functional capabilities to identify, model, and construct near ambient infrared sensing devices. Adapt characteristics of microbial and protein-based biosystems for applications to military sensor systems. Explore mimicking natural materials, using organisms as factories of new materials, or taking existing biomaterials and processing them into Air Force useful materials. Study the fundamental science and nano surface structure of biomaterials for application to military sensor systems that will ensure reliable assessment and monitoring.

(U) $14,352 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602202F, Human Effectiveness Applied Research.

(U) PE 0602204F, Aerospace Sensors.

(U) PE 0602602F, Conventional Munitions.

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

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 01 - Basic Research	PE NUMBER AND TITLE: 0601102F Defense Research Sciences — PROJECT: 2313

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
2313	Human Performance	14,097	12,700	12,776	12,218	12,337	15,489	12,767	12,958	Continuing	TBD

(U) A. Mission Description

Human Performance research provides the fundamental knowledge necessary to examine and exploit all aspects of human information processing critical to Air Force operations. The goal is to develop useful quantitative models of the way warfighters perceive, navigate, and manipulate their environment; make decisions in complex tasks under stress or uncertainty; and adapt to extreme sensory, biophysical, or cognitive workloads. Sensory research emphasizes visual, auditory, equilibrium, and kinesthetic systems and their optimal integration. Basic research topics focus investigations on the scientific foundation for nascent Air Force technologies including specialized interactive displays, simulators, intelligent control systems, sensors and fused-image displays, and adaptive systems for operator and team training. The primary areas of research investigated by this project are sensory and perceptual systems, cognition, and team performance.

(U) FY 2002 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,807	Performed sensory and perceptual system research to investigate sensory and perceptual systems to enhance human-machine interaction in Air Force weapon systems. Further developed theories for models of human-machine interaction in Air Force weapon systems. Critically assessed theories of visual search and scene analysis, and control of attention using measures of performance identified in several task domains. Developed models for perceptual and cognitive requirements for accurate simulation and for effective design of informative displays. Designed laboratory apparatus to test theories of sensory integration for image understanding.
(U)	$5,355	Conducted cognition research to measure and analyze cognitive dimensions of human performance in complex command and control tasks with multiple crewmember interactions. Developed models of enhanced human performance aided or augmented by intelligent systems. Discovered and evaluate theories of training for operator and team effectiveness under stress and sustained operation.
(U)	$4,935	Studied cognitive workload to validate behavioral and physiological measures of cognitive workload, alertness, and vulnerability to sleep loss in several domains of operator performance. Modeled relationships between individual skill differences and interactions with new training methodologies. Studied behavioral and physiological measures to avert human error in conditions of information overload and fatigue.
(U)	$14,097	Total

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PROJECT 2313	

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,485	Perform sensory and perceptual system research to investigate sensory and perceptual systems to enhance human-machine interaction in Air Force weapon systems. Critically test theories of sensory and perceptual systems for enhanced human-machine interaction and sensor processing in Air Force weapon systems. Investigate novel methods for evaluating design options for visual displays used in scene analysis and command and control in several task domains. Evaluate theories and models of perception and cognition for accurate simulation and fused sensor processing. Using performance metrics, critically test theories of sensory integration for image understanding.
(U)	$4,771	Conduct cognition research to measure and analyze cognitive dimensions of human performance in complex command and control tasks with multiple crewmember interactions. Extend models of cognitive dimensions of human performance in complex command and control tasks to inform studies of automated decision making. Test models of enhanced human performance aided or augmented by intelligent systems. Determine mechanisms affecting training effectiveness for operator and team performance under stress and sustained operation.
(U)	$4,444	Study cognitive workload by using developed metrics to critically test behavioral and physiological theories of cognitive workload, alertness, and vulnerability to sleep loss in several domains of operator performance. Develop theories for modeled relationships between individual skill differences and interactions with envisioned training pedagogies. Determine behavioral and physiological measures to avert human error in conditions of information overload and fatigue.
(U)	$12,700	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,468	Investigate sensory and perceptual systems to enhance human-machine interaction in Air Force weapon systems and to enable the capturing and exploiting of pertinent environment information. Critically investigate and model theories of sensory and perceptual systems. Explore visual information processing techniques to improve methods for evaluating display designs and enhance capability for collaboration and movement and sharing of information. Evaluate theories and models of perception and cognition for more accurate simulation and improved fusion of sensor data. Using performance metrics, critically test theories of sensory integration to understand complex images.
(U)	$4,813	Conduct research to model and assess cognitive dimensions of warfighter performance in complex command and control tasks including those involving multiple crewmember interactions. Extend models of the cognitive dimensions of human performance in complex command and control tasks to enable studies of automated decision-making and enhanced risk assessment and measured response. Test models for enhanced human performance aided or augmented by intelligent systems. Continue studies to determine mechanisms affecting training effectiveness for ensuring operator and team performance under stress and sustained operations.

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	PROJECT 2313

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$4,495	Study cognitive workload by using developed metrics to critically test behavioral and physiological theories of cognitive workload, alertness, and vulnerability to sleep loss in several domains of operator performance. Develop theories for modeled relationships between individual skill differences and interactions with envisioned training techniques. Determine behavioral and physiological measures to avert human error in conditions of information overload and fatigue and maintain full spectrum air and space vigilance.
(U)	$12,776	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602202F, Human Effectiveness Applied Research.

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

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)

DATE: February 2003

BUDGET ACTIVITY: 01 - Basic Research

PE NUMBER AND TITLE: 0601102F Defense Research Sciences

PROJECT: 4113

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4113	External Research Programs Interface	6,321	7,205	7,409	7,605	7,403	7,748	7,708	7,827	Continuing	TBD

(U) A. Mission Description

External research programs interface optimizes interactions between the international and domestic research communities and U.S. Air Force researchers. These professional interchanges and collaborations stimulate scientific and engineering education beneficial to the Air Force, increase the awareness of Air Force basic research priorities, and attract talented scientists and engineers to address Air Force needs. International interactions ensure future interoperability of coalition systems and foster relationships with future coalition partners. Projects also seek to enhance educational interactions with historically black colleges and universities, Hispanic serving institutions, and minority institutions. The primary elements of this effort are international strategy, international technology liaison, and scientist and engineer research interchange.

(U) FY 2002 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,084	Supported the Air Force Research Laboratory international strategy mission to provide centralized international expertise to assist in the formulation of optimal cooperation with, and leveraging of, foreign science programs to the benefit of the Air Force. Provided the primary interface with Office of the Secretary of Defense, the Office of the Secretary of the Air Force, and Air Force Materiel Command to coordinate international participation among appropriate U.S. Department of Defense organizations.
(U)	$2,466	Supported international technology liaison missions to identify unique international research capabilities, and make them available to the U.S. Air Force. Used the European Office of Aerospace Research and Development and the Asian Office of Aerospace Research and Development to provide on-site coordination with international research organizations, and support international visits of high-level Department of Defense delegations. Sustained and funded Air Force commitment to NATO-affiliated research institutes, such as the Von Karman Institute.
(U)	$1,771	Supported scientist and engineer exchange efforts to assure the Air Force of continuing availability of superior scientific and engineering talent by supporting exceptional individuals and forging relationships between premier scientists and the Air Force Research Laboratory. Improved awareness of Air Force research needs throughout the civilian scientific community while simultaneously identifying and recruiting the best scientific talent to participate in critical Air Force research.
(U)	$6,321	Total

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BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences
	PROJECT 4113

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,384	Support the Air Force Research Laboratory international strategy mission to provide centralized international expertise to assist formulation of optimal cooperation with, and leveraging of, foreign science programs to the benefit of the Air Force. Provide the primary interface with the Office of the Secretary of Defense, the Office of the Secretary of the Air Force, and the Air Force Materiel Command to coordinate international participation among appropriate U.S. Department of Defense organizations.
(U)	$2,813	Support international technology liaison missions to identify unique international research capabilities, and make them available to the U.S. Air Force. Through the European Office of Aerospace Research and Development and the Asian Office of Aerospace Research and Development provide on-site coordination with international research organizations and support international visits of high level Department of Defense delegations. Sustain and fund Air Force commitment to NATO-affiliated research institutes, such as the Von Karman Institute.
(U)	$2,008	Support scientist and engineer education at U.S. colleges and universities, including historically black colleges and universities and minority institutions, to assure the Air Force of continuing availability of superior scientific and engineering talent by supporting exceptional individuals and forging associateships between premier scientists and the Air Force Research Laboratory. Improve awareness of Air Force research needs throughout the civilian scientific community while simultaneously identifying and recruiting the best scientific talent to participate in critical Air Force research.
(U)	$7,205	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,458	Support the Air Force Research Laboratory international strategy mission. Provide centralized international expertise to assist formulation of optimal cooperation with, and leveraging of, foreign science programs to the benefit of the U.S. Air Force. Provide the primary interface with the Office of the Secretary of Defense, the Office of the Secretary of the Air Force, and the Air Force Materiel Command to coordinate international participation among appropriate U.S. Department of Defense organizations.
(U)	$2,866	Support international technology liaison missions. Identify unique international research capabilities making them accessible to the U.S. Air Force. Through the European Office of Aerospace Research and Development and the Asian Office of Aerospace Research and Development, provide on-site coordination with international research organizations and support international visits of high-level Department of Defense delegations. Sustain and fund Air Force commitment to NATO-affiliated research institutes, such as the Von Karman Institute.
(U)	$2,085	Support scientist and engineer education research programs at U.S. colleges and universities, including historically black colleges and universities, Hispanic serving institutions, and minority institutions. Assure the Air Force of continued superior scientific and engineering talent

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BUDGET ACTIVITY 01 - Basic Research	PE NUMBER AND TITLE 0601102F Defense Research Sciences
	PROJECT 4113

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

by supporting exceptional individuals and forging associations between premier scientists and the Air Force Research Laboratory. Improve awareness of Air Force research needs throughout the civilian scientific community while simultaneously identifying and recruiting the best scientific talent to participate in critical Air Force research.

(U) $7,409 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0601103D, University Research Initiative.
(U) PE 0602102F, Materials.
(U) PE 0602201F, Aerospace Flight Dynamics.
(U) PE 0602202F, Human Effectiveness Applied Research.
(U) PE 0602203F, Aerospace Propulsion.
(U) PE 0602204F, Aerospace Avionics.
(U) PE 0602269F, Hypersonic Technology Program.
(U) PE 0602500F, Multi-Disciplinary Space Technology.
(U) PE 0602601F, Space Technology.
(U) PE 0602602F, Conventional Munitions.
(U) PE 0602702F, Command, Control and Communication.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.