PE NUMBER: 0602500F
PE TITLE: MULTI-DISCIPLINARY SPACE TECH

Exhibit R-2, RDT&E Budget Item Justification

DATE: February 2004

BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH

	Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
	Total Program Element (PE) Cost	95.779	101.360	84.581	81.118	101.359	123.236	122.071	0.000	0.000
5023	Laser & Imaging Space Tech	1.176	6.059	8.546	8.071	10.459	11.472	11.672	0.000	0.000
5024	Human Centered Applied Space Tech	0.475	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5025	Space Materials Development	17.625	19.447	21.499	20.797	26.531	36.390	35.919	0.000	0.000
5026	Rocket Propulsion Component Tech	22.410	51.909	40.961	42.123	44.413	45.360	46.357	0.000	0.000
5027	High Speed Airbreathing Prop Tech	4.014	4.549	0.180	0.250	0.255	0.260	0.264	0.000	0.000
5028	Space Sensors, Photonics & RF Proc	42.182	1.676	1.856	1.953	4.210	4.265	4.322	0.000	0.000
5029	Space Sensor & CM Tech	6.665	10.599	5.213	1.526	5.089	7.145	6.126	0.000	0.000
5030	Applied Space Access Vehicle Tech	1.232	0.000	0.000	0.000	3.907	8.246	7.321	0.000	0.000
5081	Space Antennas Tech	0.000	1.056	1.406	1.509	1.617	5.233	5.237	0.000	0.000
5082	Optical Networking Tech	0.000	6.065	4.920	4.889	4.878	4.865	4.853	0.000	0.000

Note: In FY 2003, this was a new PE, but not a New Start, resulting from the Space Commission recommendation to consolidate all space unique activities. In FY 2003, space unique efforts in the following PEs/Projects transferred to this PE in conjunction with the Space Commission recommendation: PE 0602102F, Projects 4347, 4348, 4349, and 5015, to Project 5025; PE 0602201F, Project 2403, to Project 5030; PE 0602202F, Project 7184, to Project 5024; PE 0602203F, Project 4847, to Project 5026; PE 0602203F, Project 3012, to Project 5027; PE 0602204F, Project 2002, to Project 5028; Projects 2002, 6095, and 7622, to Project 5029; PE 0602605F, Project 4866, to Project 5023. In FY 2004, efforts in Projects 5024 were terminated and efforts in Project 5030 were delayed until FY 2007 due to higher Air Force priorities. Also in FY 2004, space antenna efforts in PE 0602204F, Project 4916, were transferred to this PE, Project 5081, and the Air Force increased emphasis on developing optical networks for space-based applications in Project 5082. In addition, changes are due to adjustments based on recategorization of space unique tasks.

(U) A. Mission Description and Budget Item Justification

PE Description: This program advances the technology base in multiple disciplines for future space applications in eight projects, each focusing on a separate technology area including: 1) Laser and imaging space technologies develop concepts for advanced, very long-range optical systems and assess the vulnerability of satellites to the effects of high energy laser weapon systems. 2) Human centered applied space technologies focus on the human interface concepts that improve satellite operations during routine and on-demand space missions. 3) Space materials concentrate on the materials technology base for spacecraft and launch systems to improve affordability, maintainability, and performance. 4) Rocket propulsion component technologies advance technology in liquid propulsion rocket engines, solid rocket motors, spacecraft and upper stage propulsion, ballistic missiles, and application of advanced materials for rockets to achieve revolutionary launch capabilities. 5) High-speed airbreathing propulsion technologies develop advanced and combined cycle engine technologies for revolutionary low-cost access to space. 6) Photonics and radio frequency processes develop technologies to generate, control, process, receive, and transmit opto-electronic signals for space sensor applications. 7) Space sensors and countermeasures technologies focus on generation, control, reception and processing of electronic and electromagnetic signals for space sensor applications in intelligence, surveillance, reconnaissance, warning, electronic combat, and countermeasures. 8) Applied space access vehicle technologies develop advanced concepts for affordable on-demand access to space. 9) Lightweight satellite antenna technology and affordable antenna terminal technology for communications and surveillance. 10) Optical networking

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technology focuses on the space-based laser communications to provide the warfighter with unlimited communications to any place at any time. Note: In FY 2004, Congress added $1.0 million for the Starfire Optical Range Coating Facility, $1.0 million for the Launch Vehicle Engine Project, $10.7 million for the Jet and Rocket Engine Test Site, and $1.0 million for Photonics Technology.

This program is in Budget Activity 2, Applied Research, since it develops and determines the technical feasibility and military utility of evolutionary and revolutionary technologies.

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

		FY 2003	FY 2004	FY 2005
(U)	Previous President's Budget	98.929	90.526	91.185
(U)	Current PBR/President's Budget	95.779	101.360	84.581
(U)	Total Adjustments	-3.150	10.834	
(U)	Congressional Program Reductions		-2.000	
	Congressional Rescissions		-0.866	
	Congressional Increases		13.700	
	Reprogrammings			
	SBIR/STTR Transfer	-3.150		

(U) Significant Program Changes:

This is a new PE, but not a New Start, resulting from the Space Commission recommendation to consolidate all space unique activities. In FY 2005, funding reductions due to higher Air Force priorities.

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BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT NUMBER AND TITLE: 5023 Laser & Imaging Space Tech

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5023 Laser & Imaging Space Tech	1.176	6.059	8.546	8.071	10.459	11.472	11.672	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique efforts transferred from PE 0602605F, Project 4866, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, increase is primarily due to the transfer of civilian salaries related to space unique activities into this project.

(U) A. Mission Description and Budget Item Justification

This project examines the technical feasibility of space-oriented laser and imaging technologies/concepts including advanced, very long-range optical system concepts for both imaging and beam projection applications. It also supports the modeling and analysis of satellite objects to assess vulnerability to laser radiation and to support the space situational awareness mission.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop advanced long-range optical technologies such as advanced beam control; beam acquisition, tracking, and pointing; adaptive optics; dual line of sight pointing; large, lightweight optics; and optical coatings (low energy and high energy) that support relay mirrors. Relay mirrors can greatly extend the range of high power laser weapons as well as low power imaging systems.	0.589	2.920	6.433
(U) In FY 2003: Developed advanced long-range optical technologies such as space-based relay mirrors to support beam projection and imaging applications. Developed technologies such as beam control; acquisition, tracking, and pointing; dual line of sight pointing; and beam stabilization. Developed a roadmap for relay mirror technology development. Developed lightweight, low power optics for space-based relay mirrors. Produced and tested one-meter class ultra-light mirror with near final curvature and demonstrated correction of the mirror surface.			
(U) In FY 2004: Develop technologies for lightweight primary mirrors applicable to bifocal relay mirrors. Investigate different solutions for spacecraft and optical control dynamics.			
(U) In FY 2005: Develop critical optical technologies. Transition mature technologies to a relay mirror system for developmental and field tests and ultimately a demonstration.			
(U)			
(U) MAJOR THRUST: Assess the vulnerability of satellites to the effects of high-energy laser weapons and maintain and update catalogued satellites.	0.587	2.139	2.113
(U) In FY 2003: Incorporated improved algorithms and hardware for rapidly characterizing new launches into current data fusion workstations for the space situational awareness mission.			
(U) In FY 2004: Develop finite state models for space systems that will enable rapid characterization of new launches and provide a better estimate of on orbit space systems capabilities for improved space situational awareness.			
(U) In FY 2005: Update target system response databases for continued improvement of predictive avoidance analyses			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
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and provide data to U.S. Space Command for the performance of Laser Clearinghouse functions. Update previously completed assessments on catalogued satellites. Enhance and refine finite state modeling process and models for space systems that will enable rapid characterization of new launches and provide a better estimate of on-orbit space systems capabilities for improved space situational awareness. Update lethality assessment methodology by anchoring modeling tools to empirical data. Perform finite state modeling of laser targets to better understand vulnerabilities and identify indicators of battle damage assessment. Incorporate improved algorithms and hardware for rapidly characterizing space objects and new launches into current data fusion workstations needed for satellite assessments and for the space situational awareness mission.

(U)

(U)	CONGRESSIONAL ADD: Starfire Optical Range Coating Facility.	0.000	1.000	0.000
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Develop a mirror recoating chamber for the Starfire Optical Range 3.5 meter telescope primary mirror, with the capability to coat other large mirrors as needed. Design and build the equipment needed for washing, stripping, and vapor deposition aluminum coating of 2-4 meter diameter mirrors and integrate with large mirror coating room.			
(U)	In FY 2005: Not Applicable.			
(U)	Total Cost	1.176	6.059	8.546

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602605F, Directed Energy Technology.									
(U) PE 0603444F, Maui Space Surveillance Systems.									
(U) PE 0603500F, Multi-Disciplinary Adv Dev Space Technology.									
(U) PE 0603605F, Advanced Weapons Technology.									
(U) This project has been coordinated through the Reliance process to harmonize									

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

efforts and eliminate
duplication.

(U) D. Acquisition Strategy

Not Applicable.

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BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT NUMBER AND TITLE: 5024 Human Centered Applied Space Tech

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5024 Human Centered Applied Space Tech	0.475	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique efforts transferred from PE 0602202F, Project 7184, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, efforts in this project were terminated due to higher Air Force priorities within the Science and Technology Program..

(U) A. Mission Description and Budget Item Justification

This project identifies and develops human and crew interface concepts and technologies that improve satellite operations, satellite attack reporting, and crew situational awareness during routine and on-demand space missions. Payoffs include faster satellite reconfiguration for time-critical targeting, improved situational awareness of space battlespace, and lower cost for operations, training, and modernization due to reduced manning and control station standardization.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop new crew interface concepts and identify new human roles for space operations.	0.475	0.000	0.000
(U) In FY 2003: Developed and evaluated new crew interface concepts for satellite attack reporting, having the optimal mix of human interface technologies that maximize crew situational awareness. Identified new human roles for on-orbit servicing, prepared a satellite control station simulator as an evaluation testbed, and began to develop a multi-sensory control station interface usable across systems.			
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Not Applicable.			
(U) Total Cost	0.475	0.000	0.000

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602202F, Human Effectiveness Applied Research. This project has been coordinated through the									
(U) Reliance process to harmonize efforts and eliminate duplication.									

(U) D. Acquisition Strategy

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BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5024 Human Centered Applied Space Tech**

Not Applicable.

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BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT NUMBER AND TITLE: 5025 Space Materials Development

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5025 Space Materials Development	17.625	19.447	21.499	20.797	26.531	36.390	35.919	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique efforts were transferred from PE 0602102F, Projects 4347, 4348, 4349, and 5015, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, the civilian salaries related to these space unique activities transfer into this project.

(U) A. Mission Description and Budget Item Justification

This project develops the materials and processing technology base for spacecraft and launch systems to improve affordability, maintainability, and performance of current and future Air Force space systems. Families of affordable lightweight materials are being developed, including metals, polymers, ceramics, metallic composites, and nonmetallic composites, to provide new capabilities for spacecraft, ballistic missile, and propulsion systems to meet the future space requirements. Rocket propulsion materials development in this project supports the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) Program. Advanced high-temperature protection materials are being developed that are affordable, lightweight, dimensionally stable, thermally conductive, and/or ablation and erosion resistant to meet space and ballistic missile requirements. Materials technologies are also being developed to enable surveillance and terrestrial situational awareness systems and subsystems for space and ballistic missile applications.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop materials and processes to dramatically improve performance, durability, and cost of rocket propulsion systems.	10.877	10.410	11.176

(U) In FY 2003: Evaluated new candidate materials for rocket engines such as metal matrix composites, ceramics, and advanced organic composites for use in liquid oxygen, liquid hydrogen, high-temperature, and high-pressure environments. Identified and began evaluating the applications of these materials to turbopump housings, ducts, valves, solid rocket casings, insulation, nozzle throats, and spacecraft propulsion. Developed material property databases and initiated demonstration of suitability for application using representative geometry and processing conditions for the intended rocket engine components.

(U) In FY 2004: Develop candidate materials and improve processing capabilities to ensure consistent material characteristics for high-speed turbopump housings, ducts, valves, solid rocket casings, insulation, nozzle throats, and spacecraft propulsion. Evaluate high-temperature metals, ceramics, and composite materials by fabricating test articles with representative geometry to validate material characteristics and processing capabilities for solid rocket nozzles, throats, and spacecraft propulsion. Establish materials database and provide predictive modeling capability to anticipate materials performance and model life-cycle behavior of materials in a rocket propulsion environment. Identify new candidate materials suitable for spacecraft and rocket propulsion environments such as thrust chambers, nozzles, and propellant catalysts.

(U) In FY 2005: Evaluate materials in an appropriate test environment for high-speed turbopump housings, ducts, valves,

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BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5025 Space Materials Development**

	solid rocket casings, insulation, nozzle throats, and spacecraft propulsion. Establish performance of test articles with representative geometry using high-temperature metals, ceramics, and composite materials to validate material characteristics and processing capabilities for solid rocket nozzles, throats, and spacecraft propulsion. Evaluate engine component suitability using direct replacement of materials or enabling new design based on established material properties. Evaluate materials for pursuing applications such as thrust chambers, nozzles, and propellant catalysts at high-temperature, high-pressure and cryogenic environments.			
(U)				
(U)	MAJOR THRUST: Develop nanostructured materials technology for insertion into structures, propulsion, and subsystems applications such as rocket engine components and cryogenic components and structures to enable lighter weights, better performance, and lower costs.	0.000	0.200	1.289
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Investigate nanoparticle and nanostructured fabrication, characterization, processing techniques, and models for the efficient, low-cost assembly of nanomaterials.			
(U)	In FY 2005: Develop nanoparticle and nanostructured fabrication, characterization, processing techniques, and models for the efficient, low-cost assembly of nanomaterials.			
(U)				
(U)	MAJOR THRUST: Develop affordable, advanced structural and non-structural materials and technologies for Air Force space applications.	5.383	5.756	6.890
(U)	In FY 2003: Optimized processing methods for the metallic materials which are expected to be used for lightweight, high-strength components in future space vehicles. Tested non-autoclave composite materials and processes for composite cryogenic tank structures for future Air Force space platforms. Developed optically tailorable thermal control coatings with controlled heat dissipation for spacecraft thermal control. Established baseline effects of the space environment on polymer and thermal control coatings.			
(U)	In FY 2004: Mature processing methods for the metallic materials that are expected to be used for lightweight, high-strength components in future space vehicles. Develop and fabricate high-temperature metallic gamma-titanium-aluminide technologies for reusable access to space vehicles. Develop advanced and reproducible joining processes for large metallic cryotanks. Develop analytical understanding of the behavior of composites in liquid oxygen environments and in a simulated space environment facility. Develop novel high-temperature protection system concepts for high-Mach, reentry, and access to space vehicles. Integrate carbon foam materials into space thermal management applications. Integrate foams into heat-pipe efficient radiator applications. Evaluate high-temperature organic matrix composites for tanks and structures for space access and launch vehicle applications. Fabricate laboratory-level demonstrations of optically tailorable active thermal control coatings with controlled heat dissipation for spacecraft thermal control and three-fold increase in service life. Develop baseline effects of the space environment on thermal control coatings, space lubricants, and other organic/inorganic space materials. Identify			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
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	configurations suitable for use of non-oxide ceramic composites for standoff high temperature protection systems. Develop test procedures to validate candidate space materials. Develop repair processes for non-metallic space materials.			
(U)	In FY 2005: Establish performance of high-temperature metallic high-temperature protection systems using gamma-titanium-aluminide as an external skin for reusable access to space vehicles. Assess aluminum-lithium metallic cryotank materials for multiple mission access to space. Expand experimental data and analytical results of liquid oxygen compatibility research. Continue to derive a more representative test series for composite materials. Develop subscale novel high-temperature protection systems in conditions that simulate representative reentry and high-Mach vehicles flight profiles. Mature all-composite heat-pipe radiators for Air Force space systems. Explore oxidation-protected carbon-carbon materials. Establish capability of optically tailorable active thermal control coatings with controlled heat dissipation to provide three-fold increase in service life for spacecraft thermal control. Continue developing and evaluating baseline effects of the space environment on thermal control coatings, space lubricants, and other organic/inorganic space materials. Develop non-oxide ceramic composites for standoff high temperature protection systems. Evaluate rapid inspection techniques for both advanced ceramic tile and standoff high-temperature protection system materials. Assess techniques to validate candidate space materials performance. Establish suitability of repair processes for non-metallic space materials.			
(U)				
(U)	MAJOR THRUST: Develop materials and materials processing technologies to enable improved performance and affordability of surveillance, tracking, targeting, and situational awareness systems.	1.365	3.081	2.144
(U)	In FY 2003: Refined improved thin film processing techniques to optimize efficiency in solar cells. Validated and transitioned materials processing techniques and materials that will enable high performance optical control of phased array radar and satellite-to-satellite data links. Demonstrated alternative infrared detector materials for space applications capable of detecting very long wavelengths.			
(U)	In FY 2004: Identify higher performance materials, including optical nanocomposites and exotic ferroelectronics, for advanced optical architecture in phased array radar and satellite-to-satellite data links. Scale-up very long wavelength, alternative infrared detector materials to areas suitable for the fabrication of staring focal plane arrays.			
(U)	In FY 2005: Evaluate higher performance materials, including optical nanocomposites and exotic ferroelectronics, for advanced optical architecture in phased array radar and satellite-to-satellite data links. Establish the detection performance of very long wavelength alternative materials operating at 40ºK.			
(U)	Total Cost	17.625	19.447	21.499

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

(U) D. Acquisition Strategy

Not Applicable.

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BUDGET ACTIVITY: 02 Applied Research	PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT NUMBER AND TITLE: 5026 Rocket Propulsion Component Tech	

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5026 Rocket Propulsion Component Tech	22.410	51.909	40.961	42.123	44.413	45.360	46.357	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique efforts transferred from PE 0602203F, Project 4847, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, civilian salaries transferred from PE 0602203F, Project 4847, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description and Budget Item Justification

This project develops advances in rocket propulsion technologies for space access, space maneuver, and ballistic missiles. Analytical and experimental areas of emphasis are propellants, propellant management, combustion, rocket material applications, Technology for Sustainment of Strategic Systems (TSSS) Phase 1, and novel space propulsion concepts. Technologies of interest will improve reliability, performance, survivability, affordability, and environmental compatibility of future space and missile launch subsystems. Technologies are developed to reduce the weight and cost of components using new materials and improved designs and manufacturing techniques. All efforts in this project contribute to the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program, a joint Department of Defense, National Aeronautics and Space Administration, and industry effort to focus rocket propulsion technology on national needs.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop, characterize, and test advanced hydrocarbons, energetics, and reduced-toxicity monopropellants to increase space launch payload capability and refine new propellants synthesis methods. Develop and test monopropellants with performance equivalent to bipropellants.	1.919	2.670	3.363

(U) In FY 2003: Scaled-up initial selected propellants for laboratory and demonstrator engine evaluations. Developed high-energy-density oxidizers, nano-materials, and polymeric binders and optimizing paths for incorporating these materials into propellants with significantly enhanced performance. Evaluated reduced-toxicity ionic salt monopropellants towards reducing the cost of space access and space operations. Evaluated selected propellants in advanced combustion devices to determine materials compatibility and performance. Modeled and analyzed advanced propulsion concepts such as laser-propelled lightcraft with enhanced performance and reliability.

(U) In FY 2004: Continue scale-up of selected propellants for laboratory and demonstrator engine evaluations. Continue developing high-energy-density oxidizers, nano-materials, and polymeric binders and optimizing paths for incorporating these materials into propellants with significantly enhanced performance. Expand evaluating reduced-toxicity ionic salt monopropellants towards reducing the cost of space access, space operations, and other Air Force applications. Begin development of advanced catalysts for new monopropellant formulations. Begin scale-up of promising high energy-density materials candidates. Continue to evaluate selected propellants in advanced combustion devices to determine materials compatibility and performance. Continue to model and explore advanced propulsion concepts with enhanced performance and reliability such as laser-propelled lightcraft and rocket-based

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combined cycle engines. Formulated propellant ingredients for IHPRPT-Phase III solid propellant developments and begin transition to propellant formulation.

(U) In FY 2005: Continue scale-up of selected propellants for laboratory and demonstrator engine evaluations. Continue developing high-energy-density oxidizers, nano-materials, and polymeric binders (i.e., linked heterocyclic compounds) and optimize paths for incorporating these materials into propellants with significantly enhanced performance. Continue evaluating reduced-toxicity ionic salt monopropellants towards reducing the cost of space access and space operations. Continue development of advanced catalysts for new monopropellant formulations. Continue scaling-up of promising high energy-density materials candidates. Continue to evaluate selected propellants in advanced combustion devices to determine materials compatibility and performance. Continue to model and analyze advanced propulsion concepts with enhanced performance and reliability such as laser-propelled lightcraft and rocket-based combined cycle engines. Continue maturing solid propellants ingredients into solid propellant formulations.

(U)

(U) MAJOR THRUST: Develop advanced liquid engine combustion technology for improved performance while preserving chamber lifetime and reliability needs for engine uses in heavy lift space vehicles.	0.938	4.445	7.512

(U) In FY 2003: Characterized, studied, and evaluated specific injector performance to ensure chamber/injector compatibility and prevent damage to test and operational combustion devices. Developed, analyzed, and modeled advanced combustion devices and injectors compatible with new energetic propellants. Modeled and analyzed advanced propulsion concepts, such as rocket-based combined cycle engines and pulsed detonation engines, with enhanced performance and reliability.

(U) In FY 2004: Continue to characterize, study, and evaluate injector performance to ensure chamber/injector compatibility and prevent damage to test and operational combustion devices. Continue to develop, analyze, and model advanced combustion devices and injectors compatible with new energetic propellants. Begin analyzing and testing to characterize causes and issues that lead to combustion instability in hydrocarbon fueled liquid rocket engines reducing the need for conducting large numbers of costly full-scale component and engine tests. Develop and begin transitioning advanced hydrocarbon fuels for scale-up and testing. Continue modeling and analyzing advanced propulsion concepts with enhanced performance and reliability such as common aerovehicles and potential launch systems.

(U) In FY 2005: Continue to characterize, study, and evaluate injector performance to ensure chamber/injector compatibility and prevent damage to test and operational combustion devices. Continue to develop, analyze, and model advanced combustion devices and injectors compatible with new energetic propellants. Continue analysis and testing to characterize causes and issues that lead to combustion instability in hydrocarbon fueled liquid rocket engines reducing the need for conducting large numbers of costly full-scale component and engine tests. Continue working on transition issues, testing, scale-up of advanced hydrocarbon fuels. Continue modeling and analyzing

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	advanced propulsion concepts with enhanced performance and reliability such as common aerovehicles and potential launch systems.			
(U)				
(U)	MAJOR THRUST: Develop advanced material applications for lightweight components and material property enhancements for use in rocket propulsion systems.	2.579	3.014	3.884
(U)	In FY 2003: Developed advanced ablative components with hybrid polymers for use in current and future launch systems. Characterized and developed new high temperature polymer components and carbon-carbon components for use in advanced combustion devices and propulsion systems to meet lower weight, increased strength, and lower cost requirements. Developed advanced motor casings and propellant system components for high-energy propellants.			
(U)	In FY 2004: Continue additional developing advanced ablative components with hybrid polymers for use in current and future launch systems. Continue to characterize and develop new processes for high temperature polymers and carbon-carbon materials for use in advanced combustion devices and propulsion systems to meet lower weight and increased strength requirements. Continue developing advanced material components for use with high-energy propellants. Commence transition of advanced high temperature material components to reduce system weight and cost, and increase performance. Initiate exploration of the use of nanocomposites for liquid rocket engine tanks.			
(U)	In FY 2005: Continue developing advanced ablative components using hybrid polymers for use in current and future launch systems. Continue to characterize and develop new high temperature polymers and carbon-carbon materials for use in advanced combustion devices and propulsion systems to meet lower weight and increased strength requirements. Continue developing advanced materials for use with high-energy propellants. Complete transition of specific advanced high temperature materials to air and space systems to reduce system weight and cost, and increase performance. Continue to explore using nanocomposites for liquid rocket engine tanks.			
(U)				
(U)	MAJOR THRUST: Develop propulsion component technologies for reliable, safe, and low-cost boost systems. Note: In FY 2005, these activities will be moved to the "advanced liquid engine technologies" effort in this Project.	5.079	1.386	0.000
(U)	In FY 2003: Completed development and began testing single stage hydrogen turbopump for advanced cryogenic engines. Developed components for hybrid propulsion technologies for space boosters and air-launched missiles. Tested preliminary injector for hydrocarbon or cryogenic fuel applications.			
(U)	In FY 2004: Complete testing of single stage hydrogen turbopump for advanced cryogenic engines. Complete development of components for hybrid propulsion technologies for space boosters and air launched missiles. Continue hydrocarbon fuel characterization test rig development and evaluation of potential hydrocarbon fuels.			
(U)	In FY 2005: Not Applicable.			
(U)				
(U)	MAJOR THRUST: Develop lightweight combustion devices and nozzle technologies for liquid rocket engines. Note: In FY 2004, the funding in this activity increased due to salary funds being transferred from PE 0602203F,	3.091	23.476	0.000

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5026 Rocket Propulsion Component Tech**

	Project 4847 and the reprioritization of efforts. In FY 2005, these activities will be moved to the "advanced liquid engine technologies" effort in this Project.			
(U)	In FY 2003: Developed advanced lightweight rocket engine nozzle for upper stage and space booster applications. Completed preliminary study for high-pressure turbopumps for use in advanced upper stage engines.			
(U)	In FY 2004: Continue development of an advanced lightweight altitude-compensating nozzle. Continue design studies for advanced liquid oxygen and liquid hydrogen turbopumps for the next phase of advanced upper stage engines.			
(U)	In FY 2005: Not Applicable.			
(U)				
(U)	MAJOR THRUST: Develop advanced liquid engine technologies for improved performance while increasing life and reliability needs for engine uses in expendable and reusable launch vehicles. Note: Prior to FY 2005, these activities were conducted under other efforts earlier in this Project.	0.000	0.000	21.031
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Not Applicable.			
(U)	In FY 2005: Continue development of advanced cryogenic upper stage technologies - turbopumps, thrust chambers, and modeling tools. Continue hydrocarbon fuel characterization test rig development and evaluation of potential hydrocarbon fuels. Complete development of lightweight nozzle for liquid rocket engines. Initiate technology developments for future reusable hydrocarbon based engines.			
(U)				
(U)	MAJOR THRUST: Develop missile propulsion, aging, and surveillance technology for solid rocket systems for Intercontinental Ballistic Missile (ICBM) to include testing of missile propulsion technology and Post Boost Control Systems (PBCS). Efforts support Technology for Sustainment of Strategic Systems program - Phase I. Note: After FY 2004, the efforts in this activity will be moved to the Advanced Technology Development efforts in PE 0603500F, Project 5033.	2.383	0.500	0.000
(U)	In FY 2003: Integrated aging models results and testing a database for aging and surveillance technology for ICBM fleet. Completed tools to increase the capability to determine the service life of strategic systems and other solid rocket motors. Prepared components for demonstrations of advanced lightweight solid rocket motors. Commenced development of components for demonstrations of advanced full-scale, flight-like PBCS.			
(U)	In FY 2004: Continue development and fabrication of components for demonstrations of advanced full-scale, flight like PBCS.			
(U)	In FY 2005: Not Applicable.			
(U)				
(U)	MAJOR THRUST: Develop solar electric, solar thermal, chemical, and advanced propulsion technologies for stationkeeping, repositioning, and orbit transfer for large communication satellites, microsatellites, and satellite	2.463	4.817	5.171

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
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	constellations. Phases are referring to the Integrated High Payoff Rocket Propulsion Technology program phases.			
(U)	In FY 2003: Advanced small-scale Hall thruster development efforts to achieve Air Force orbit transfers using electric propulsion. Enhanced development of microsatellites propulsion systems (e.g., plasma thrusters) for advanced imaging missions. Developed solar thrusters and concentrators for future orbital transfer vehicles. Tested a controlled solid propellant. Completed development of high power solar thermal components.			
(U)	In FY 2004: Commence development of monopropellant thruster component technologies for chemical-based space propulsion - catalyst. Continue Hall thruster development efforts (Phase III) to achieve Air Force orbit transfers using electric propulsion. Continue development of microsatellites propulsion systems (e.g., plasma thrusters) for advanced imaging missions. Continue developing solar thrusters and concentrators for future orbital transfer vehicles. Continue testing of a controlled solid propellant.			
(U)	In FY 2005: Continue development of monopropellant thruster component technologies for chemical based space propulsion - catalyst and thrust chamber. Continue Hall thruster development efforts (Phase III) to achieve Air Force orbit transfers using electric propulsion. Continue this phase of development of microsatellites propulsion systems (e.g., plasma thrusters) for advanced imaging missions. Continue developing solar thrusters and concentrators for future orbital transfer vehicles. Continue testing of a controlled solid propellant.			
(U)				
(U)	CONGRESSIONAL ADD: Engineering Tool Improvement Program (ETIP).	1.979	0.000	0.000
(U)	In FY 2003: Assessed and verified tool performance for additional data requirements for the modeling and simulation tool against available data. Made recommendations for future modeling and data acquisition. These efforts will contribute to the ongoing development of modeling and simulation tools to analyze and predict the performance of aerospace engines and their components. Improved analytical tools associated with aerospace engines with the main focus on high performance, long life, advanced cooling techniques, and combustion stability.			
(U)	In FY 2004: Not Applicable.			
(U)	In FY 2005: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Integrated High Payoff Rocket Propulsion Technology.	1.979	0.000	0.000
(U)	In FY 2003: Developed propellant formulations for space lift applications. Conducted additional risk reduction for liquid boost engine development.			
(U)	In FY 2004: Not Applicable.			
(U)	In FY 2005: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Launch Vehicles Engine Project.	0.000	0.992	0.000
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Conduct studies and develop hardware for proof of concept for a low cost launch vehicle engine with			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
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400,000 pound of thrust using liquid oxygen and hydrogen as propellants. It will fill a gap in the assured access to space a potential alternative upper stage engine and as the main engine for a low-cost consumables booster that was defined in a Space Systems Loral study in FY 2002 under the California State Space Grant program.

(U) In FY 2005: Not Applicable.

(U)

(U)	CONGRESSIONAL ADD: Jet and Rocket Engine Test Site. Note: Efforts expand upon activities initiated in a FY 2003 Congressional Add in PE 0602203F, Project 4847.	0.000	10.609	0.000
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Continue further upgrades to the rocket engine test stands at the former Norton Air Force Base in San Bernardino. Expand testing to include thermal and vibrational test capability for satellite systems.			
(U)	In FY 2005: Not Applicable.			
(U)	Total Cost	22.410	51.909	40.961

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0601102F, Defense Research Sciences.									
(U) PE 0602114N, Power Projection Applied Research.									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0602303A, Missile Technology.									
(U) PE 0602805F, Dual Use Science and Technology.									
(U) PE 0603216F, Aerospace Propulsion and Power Technology.									
(U) PE 0603500F, Multi-Disciplinary Adv Dev Space Technology.									
(U) This project has been									

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT NUMBER AND TITLE 5026 Rocket Propulsion Component Tech

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

coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: **February 2004**

BUDGET ACTIVITY: **02 Applied Research**

PE NUMBER AND TITLE: **0602500F MULTI-DISCIPLINARY SPACE TECH**

PROJECT NUMBER AND TITLE: **5027 High Speed Airbreathing Prop Tech**

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5027 High Speed Airbreathing Prop Tech	4.014	4.549	0.180	0.250	0.255	0.260	0.264	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique efforts transferred from PE 0602203F, Project 3012, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description and Budget Item Justification

This project develops revolutionary, airbreathing, hypersonic propulsion technology options to enable affordable, on demand access to space for the Air Force. The short-term focus is on hydrocarbon fueled engines capable of operating over a broad range of flight Mach numbers and longer term focus will be on hydrogen fueled scramjet powered engines that can enable the higher Mach numbers to achieve access to space. Technologies developed under this program enable capabilities of interest to both the Department of Defense and the National Aeronautical and Space Administration. Efforts include modeling and simulation, proof of concept tests of critical components, advanced component development, and ground-based tests.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Conduct studies and develop hypersonic flight demonstrator vehicle concepts. Note: In FY 2004, these activities were moved to PE 0602203F, Project 3012 to consolidate all 6.2 scramjet demonstration efforts.			
(U) In FY 2003: Developed preliminary flight demonstrator vehicle concepts. Conducted vehicle design trades for integration of hydrocarbon fueled scramjet engine.	0.223	0.000	0.000
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) MAJOR THRUST: Conduct assessments, system design trades, and simulations to integrate combined cycle engines (CCEs) and advanced cycle airbreathing hypersonic propulsion technologies in support of the development of affordable, on-demand access to space vehicles to meet future warfighter needs.	0.288	0.568	0.180
(U) In FY 2003: Conducted assessment of advanced airbreathing engines and CCEs to establish and extend operability limits enabling development of low internal drag scramjet flowpath for reusable applications.			
(U) In FY 2004: Continue to conduct system trade studies to determine military payoff and establish component technology goals. Define component and engine performance objectives to enable development of affordable hypersonic CCEs.			
(U) In FY 2005: Conduct system trade studies to determine military payoff and establish component technology goals. Continue to define component and engine performance objectives to enable development of affordable hypersonic CCEs.			
(U)			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5027 High Speed Airbreathing Prop Tech**

(U)	MAJOR THRUST: Develop advanced hydrocarbon scramjet engine technologies to enable the broad application of hypersonics to meet future warfighter needs and to support flight demonstration. Note: In FY 2004, these activities were split with non-access to space activities moving to PE 0602203F, Project 3012 and access to space activities moving to the "robust hydrocarbon fueled scramjet" effort in this Project.	0.946	0.000	0.000
(U)	In FY 2003: Conducted initial feasibility assessment of variable geometry devices to increase scramjet operating range (Mach 3 to Mach 8+) to provide robust options for combined cycle engines.			
(U)	In FY 2004: Not Applicable.			
(U)	In FY 2005: Not Applicable.			
(U)				
(U)	MAJOR THRUST: Develop robust hydrocarbon fueled scramjet engine components and technologies and integrate them into advanced combined cycle engine (CCE) designs for affordable, on-demand access to space vehicles. Note: In FY 2005, these activities will be moved to PE 0602203F, Project 3012 to consolidate all 6.2 scramjet development efforts.	2.557	3.981	0.000
(U)	In FY 2003: Developed initial critical components for advanced airbreathing engines and CCEs for robust performance over extended Mach range to include efforts to improve scramjet engine operability and scalability. Initiated development of high performance/low internal drag devices.			
(U)	In FY 2004: Complete initial feasibility assessments of variable geometry devices to increase scramjet operating range (Mach 3 to Mach 8+) to provide robust options for CCEs. Continue development of advanced engine components to improve operability, scalability, and structural durability for reusable applications. Continue developing and demonstrating low internal drag flame stabilization devices. Demonstrate advanced ignition systems for scramjets. Conduct assessment of current structural concepts and identify life-limiting factors and initiate development of multi-use components. Initiate the support for development of flight test engine components			
(U)	In FY 2005: Not Applicable.			
(U)	Total Cost	4.014	4.549	0.180

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0601102F, Defense Research Sciences.									
(U) PE 0602201F, Aerospace Flight Dynamics.									
(U) PE 0602203F, Aerospace									

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT NUMBER AND TITLE 5027 High Speed Airbreathing Prop Tech

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

Propulsion.

(U) PE 0602602F, Conventional Munitions.

(U) PE 0602702E, Tactical Technology.

(U) PE 0603111F, Aerospace Structures.

(U) PE 0603216F, Aerospace Propulsion and Power Technology.

(U) PE 0603601F, Conventional Weapons Technology.

(U) Program is reported to/coordinated by the Joint Army/Navy/NASA/Air Force (JANNAF) Executive Committee.

(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: **February 2004**

BUDGET ACTIVITY: **02 Applied Research**

PE NUMBER AND TITLE: **0602500F MULTI-DISCIPLINARY SPACE TECH**

PROJECT NUMBER AND TITLE: **5028 Space Sensors, Photonics & RF Proc**

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5028 Space Sensors, Photonics & RF Proc	42.182	1.676	1.856	1.953	4.210	4.265	4.322	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique efforts transferred from PE 0602204F, Project 2002, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities.

(U) A. Mission Description and Budget Item Justification

This project focuses on developing methods of generating, controlling, receiving, transmitting, and processing photonic, optical, and opto-electronic (mixed) signals for radio frequency (RF) space sensor applications. The enabling technologies will be used for intelligence, surveillance, reconnaissance, electronic warfare, and precision engagement sensors based in space. The project aims to demonstrate significantly improved military space sensors of smaller size, lower weight, lower cost, lower power dissipation, higher reliability, and improved performance. This project also develops and assesses multi-dimensional adaptive techniques in radar technology for affordable and reliable space surveillance and reconnaissance systems.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Design and develop high performance integrated photonic technologies for use in space.	0.351	0.574	0.250
(U) In FY 2003: Designed and developed high performance integrated photonic technology link, interconnect, and switching components and subsystems for wideband RF phased array antenna beamforming/control, and for high data rate space sensors and communication systems.			
(U) In FY 2004: Fabricate and evaluate high performance integrated photonic technology link, interconnect, and switching components and subsystems for wideband radio frequency phased array antenna beamforming and control, and for high data rate space sensors and communication systems			
(U) In FY 2005: Test and evaluate high performance integrated photonic technology link, interconnect, and switching components and subsystems for wideband radio frequency phased array antenna beamforming/control, and for high data rate space sensors and communication systems.			
(U)			
(U) MAJOR THRUST: Design and develop efficient, high coefficient chip-scale optical waveguide technologies.	0.191	0.242	0.335
(U) In FY 2003: Designed and developed efficient, high coefficient chip-scale optical waveguide technology for mixed signal component subsystems.			
(U) In FY 2004: Fabricate, test, and evaluate efficient, high coefficient chip-scale optical waveguide technology for mixed signal component subsystems.			
(U) In FY 2005: Test and evaluate efficient, high coefficient chip-scale optical waveguide technology for mixed signal component subsystems.			
(U)			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004		
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5028 Space Sensors, Photonics & RF Proc**		
(U) MAJOR THRUST: Perform independent modeling, test, and evaluation for space-based sensors.		0.333	0.242	0.183
(U) In FY 2003: Performed independent modeling, test, and evaluation for space-qualified photonic components and integrated electro-optical devices for space-based sensors.				
(U) In FY 2004: Apply the results of modeling, test, and evaluation for space-qualified photonic components and integrated electro-optical devices for space-based sensors to component architectures for high data rate space sensors and communication systems.				
(U) In FY 2005: Design and develop photonic digital and analog mixed signal multi-gigahertz component architectures for high data rate space sensors and communication systems.				
(U)				
(U) MAJOR THRUST: Study adaptive processing techniques for large, multi-mission, space-based conformal arrays.		0.096	0.618	1.088
(U) In FY 2003: Studied adaptive processing techniques for large, multi-mission, space-based conformal arrays.				
(U) In FY 2004: Continue to study and analyze adaptive processing techniques for large, multi-mission, space-based, adaptive conformal arrays.				
(U) In FY 2005: Develop adaptive processing techniques suitable for implementation on space-qualified computing architectures for multi-intelligence ISR sensing from space-based platforms.				
(U)				
(U) CONGRESSIONAL ADD: Defense Emergency Response Fund (DERF) Ground Moving Target Indication and Airborne Moving Target Indication Research		41.211	0.000	0.000
(U) In FY 2003: Developed a system brassboard of the Active Electronic Scanned Antenna and On-Board Processor (AESA/OBP) to demonstrate the technology readiness of the most critical element of an affordable Space-Based Radar. Developed the processing architecture, adaptive signal processing algorithms, and fault tolerant, radiation resistant processing for OBP in a space environment. Developed Battle-Management Command, Control and Communications techniques for multiple satellite tasking, target tracking, and moving target exploitation. Refined and validated Space-Based Radar and Moving Target Exploitation simulation capabilities to serve as a development tool for both short term acquisition and longer term capability enhancement. Developed and validated both Ground Moving Target Indication and Airborne Moving Target Indication processing algorithms for environments with clutter and interference.				
(U) In FY 2004: Not Applicable.				
(U) In FY 2005: Not Applicable.				
(U) Total Cost		42.182	1.676	1.856

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT NUMBER AND TITLE 5028 Space Sensors, Photonics & RF Proc

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

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2004

BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT NUMBER AND TITLE: 5029 Space Sensor & CM Tech

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5029 Space Sensor & CM Tech	6.665	10.599	5.213	1.526	5.089	7.145	6.126	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique efforts transferred from PE 0602204F, Projects 2002, 6095, and 7622, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, increases are due to the transfer of civilian salaries related to space unique activities into this project.

(U) A. Mission Description and Budget Item Justification

This project focuses on developing processes and techniques for electronic and electromagnetic signal processing for intelligence, surveillance, and reconnaissance (ISR) space sensor applications. This project develops the baseline technologies required to manage and perform on-board space sensor information fusion for timely and comprehensive communications and situational awareness. Through modeling and simulation, this project develops and evaluates innovative electromagnetic and electronic countermeasures for space applications.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop compact, affordable, multi-function receiver/exciter and phased array components for communications, Global Positioning System (GPS), radar, electronic warfare, and other Intelligence, Surveillance, and Reconnaissance (ISR) space sensors.	1.709	2.316	0.000
(U) In FY 2003: Fabricated critical components consisting of gallium arsenide, indium phosphide, silicon, and/or wide bandgap devices for use in multi-mode/multi-function digital receiver prototype modules, and demonstrated a feasible architecture for performing wideband direct digital synthesis from space platforms.			
(U) In FY 2004: Fabricate and test compact, affordable, multi-function receiver/exciter and phased array components for communications, GPS, radar, electronic warfare, and other ISR space sensors. Evaluate integrating these components into operational radar and electronic warfare digital receiver/exciter modules. Demonstrate a feasible architecture for performing wideband direct digital synthesis from aerospace platforms. Perform a component evaluation of an electronic/photonic digital receiver for Moving Target Indication and Synthetic Aperture Radar applications.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) MAJOR THRUST: Develop and integrate microwave technologies for advanced radio frequency (RF) apertures and phased array antennas used in military ISR space sensors.	0.087	1.206	1.715
(U) In FY 2003: Developed robust components for L-band and X-band transmitter and receiver (T/R) channels that operate with limited environmental controls and under severe electromagnetic signals.			
(U) In FY 2004: Develop the proof of concept of T/R channels that are able to withstand radiation, limited or no active cooling, and strong, undesired electromagnetic radiation.			
(U) In FY 2005: Develop T/R channels that are able to withstand radiation, limited or no active cooling, and strong,			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004		
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5029 Space Sensor & CM Tech**		

	undesired electromagnetic radiation.			
(U)				
(U)	MAJOR THRUST: Develop X-band sub-assemblies based on flexible radio frequency (RF) membranes.	0.514	0.540	0.507
(U)	In FY 2003: Developed X-band sub-assemblies based on flexible RF membranes that enable low-cost and low mass band transmitter and receiver channels integrated at the subarray level for space applications.			
(U)	In FY 2004: Develop a large area (>0.5 m2) active aperture based on flexible RF membranes that lowers the assembly costs and mass over conventional phased arrays by an order of magnitude.			
(U)	In FY 2005: Develop and investigate approaches and techniques to produce large area (>40 m2) active spaceborne aperture using advanced highly integrated and lightweight radio frequency subassemblies. Demonstrate ten-fold reduction in assembly cost and aperture mass.			
(U)				
(U)	MAJOR THRUST: Develop space-qualified micro-electro-mechanical systems phase shifters.	0.101	0.000	0.000
(U)	In FY 2003: Characterized and matured space-qualified micro-electro-mechanical systems phase shifters for extended switch lifetimes and able to operate over a ten-to-one bandwidth.			
(U)	In FY 2004: Not Applicable.			
(U)	In FY 2005: Not Applicable.			
(U)				
(U)	MAJOR THRUST: Develop two- and three-dimensional interconnects for space applications.	0.514	0.433	0.456
(U)	In FY 2003: Refined materials and processes for two-dimensional and three-dimensional interconnects for space applications.			
(U)	In FY 2004: Develop mixed signal receiver/processor multi-functionality on flexible RF membranes using advanced two-dimensional and three-dimensional interconnects.			
(U)	In FY 2005: Perform environmental testing of the multi-functional flex assemblies two-dimensional and three-dimensional interconnect approaches to determine their applicability for operation in a hostile environment.			
(U)				
(U)	MAJOR THRUST: Develop techniques to accurately predict scattering phenomenology associated with electromagnetic radiation.	0.620	0.559	0.557
(U)	In FY 2003: Refined the accuracy of predictions of the scattering phenomenology associated with electromagnetic radiation returned from objects or backgrounds when viewed from space.			
(U)	In FY 2004: Further refine the accuracy of exploitation of the scattering phenomenology associated with electromagnetic radiation returned from objects or backgrounds when viewed from space.			
(U)	In FY 2005: Complete refinement of the accuracy of exploitation of the scattering phenomenology associated with electromagnetic radiation returned from objects or backgrounds when viewed from space. Evaluate performance and enhancements to target recognition using these techniques.			

Exhibit R-2a, RDT&E Project Justification			DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5029 Space Sensor & CM Tech**	

(U)				
(U)	MAJOR THRUST: Develop space-qualified precision time, position, and velocity sensors capable of operating in jamming environments enabling multiple platform sensor-to-shooter operations.	1.530	3.203	1.638
(U)	In FY 2003: Developed Global Positioning System (GPS) specific jamming mitigation techniques for operation in hostile radio frequency (RF) environments with emphasis on synergistic integration of anti-jam technologies. Developed virtual flight test technology for improved assessment of reference sensors for space applications.			
(U)	In FY 2004: Design robust precision time, position, and velocity sensor technologies for multi-platform sensor-to-shooter network-centric engagement. Develop synergistic global positioning system jamming mitigation techniques for operation in hostile RF environments.			
(U)	In FY 2005: Develop robust precision time, position, and velocity sensor technologies for multi-platform network centric engagement. Evaluate synergistic GPS jamming mitigation techniques for operation in hostile RF environments			
(U)				
(U)	MAJOR THRUST: Develop technology to enable affordable upgrades to space-qualified radio frequency signal receivers.	1.590	0.342	0.340
(U)	In FY 2003: Modeled threat identification algorithms for next generation threat warning receivers. Evaluated state-of-the-art radar and electronic warfare (EW) digital receiver subsystems with Gallium Arsenide and Indium Phosphide radio frequency components (Analog-to-Digital Convertors, filters, mixers, etc.) for laboratory environment scenario testing.			
(U)	In FY 2004: Continue modeling threat identification algorithms for next generation threat warning receivers. Continue evaluating state-of-the-art digital and software receiver techniques for radar, electronic warfare, and narrowband space applications.			
(U)	In FY 2005: Model threat identification algorithms for next generation threat warning receivers. Evaluate state-of-the-art digital and software receiver techniques for radar, electronic warfare, and narrowband space applications.			
(U)				
(U)	MAJOR THRUST: Develop technology for an affordable Space-Based Radar.	0.000	2.000	0.000
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Further develop a system brassboard of the Active Electronic Scanned Antenna and On-Board Processor to demonstrate the technical readiness of the most critical element of an affordable Space-Based Radar. Note: In FY 2003 this work was started in Project 5028 under this program element.			
(U)	In FY 2005: Not Applicable.			
(U)	Total Cost	6.665	10.599	5.213

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT NUMBER AND TITLE 5029 Space Sensor & CM Tech

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

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2004

BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT NUMBER AND TITLE: 5030 Applied Space Access Vehicle Tech

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5030 Applied Space Access Vehicle Tech	1.232	0.000	0.000	0.000	3.907	8.246	7.321	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2003, space unique efforts transferred from PE 0602201F, Project 2403, into this project in conjunction with the Space Commission recommendation to consolidate all space unique activities. In FY 2004, efforts in this project were delayed until FY 2007 due to higher Air Force priorities.

(U) A. Mission Description and Budget Item Justification

This project develops technologies in areas of advanced structures, flight controls, and aerodynamics to enable affordable on-demand military access to space. Resulting technologies contribute significantly towards the development of reliable, responsive space access systems with aircraft-like operations. Payoffs to the warfighter include enhanced mission effectiveness, improved flight safety, improved maintenance, and decreased size, weight, and cost.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop advanced structure, flight control, and aerodynamic technologies to enable horizontal launch for affordable on-demand military access to space.	1.232	0.000	0.000
(U) In FY 2003: Developed advanced structure, flight control, and aerodynamic technologies to enable aircraft-like operations for affordable on-demand military access to space. Defined and developed integrated guidance and control laws to expand the launch vehicle performance envelope. Developed capability to simulate space access operability in a virtual environment.			
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Not Applicable.			
(U) Total Cost	1.232	0.000	0.000

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) Related Funding:									
(U) PE 0602201F, Aerospace Flight Dynamics.									
(U) PE 0602202F, Human Effectiveness Applied Research.									
(U) PE 0602204F, Aerospace Sensors.									
(U) PE 0603211F, Aerospace									

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT NUMBER AND TITLE 5030 Applied Space Access Vehicle Tech

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

Technology Dev/Demo.
This project has been
coordinated through the
(U) Reliance process to harmonize
efforts and eliminate
duplication.

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2004
BUDGET ACTIVITY: 02 Applied Research	PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH	PROJECT NUMBER AND TITLE: 5081 Space Antennas Tech	

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5081 Space Antennas Tech	0.000	1.056	1.406	1.509	1.617	5.233	5.237	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2004, space antenna efforts in PE 0602204F, Project 4916 transfer to this project.

(U) A. Mission Description and Budget Item Justification

This project develops the technology base for lightweight satellite antenna technology and affordable antenna terminal technology for communications and surveillance. Enabling antenna technologies developed under this project for satellite terminals and satellite tracking will focus on significantly lowering the life cycle cost of sensors and communications system ownership, while increasing performance. Novel antenna architectures based on emerging technologies such as Micro-Electro-Mechanical Systems, nanostructures, metamaterials, rigidizable systems, and adaptive polymers will be developed. The project will include new approaches to multi-layer microstrip and stripline feed networks for limited scan, and planar and conformal architectures using overlapped subarrays. Digital Beamforming (DBF) on transmit and receive will be implemented in order to achieve simultaneous multiple-beams, conformal array beamforming, array pattern synthesis, and neural beamforming.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop lightweight antenna technologies concepts that enable affordable deployment of space sensors for low life cycle cost communications, detection of air and ground moving targets, and remote sensing.	0.000	0.336	0.451
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Develop lightweight antenna technologies concepts that enable affordable deployment of space sensors for low life cycle cost communications, detection of air and ground moving targets, and remote sensing.			
(U) In FY 2005: Evaluate lightweight antenna technologies concepts that enable affordable deployment of space sensors for low life cycle cost communications, detection of air and ground moving targets, and remote sensing.			
(U)			
(U) MAJOR THRUST: Develop new lightweight radiators, transmission mechanisms, and control components and concepts for advanced wideband phased array antenna architectures.	0.000	0.316	0.429
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Develop new lightweight radiators, transmission mechanisms, and control components and concepts for advanced wideband phased array antenna architectures.			
(U) In FY 2005: Evaluate new lightweight radiators, transmission mechanisms, and control components and concepts for advanced wideband phased array antenna architectures.			
(U)			
(U) MAJOR THRUST: Develop concepts for Digital Beamforming on both transmit and receive cycles in order to implement simultaneous multiple-beams, conformal array beamforming, array pattern synthesis, and neural beamforming.	0.000	0.404	0.526

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5081 Space Antennas Tech**

(U) In FY 2003: Not Applicable.

(U) In FY 2004: Develop concepts for Digital Beamforming (DBF) on both transmit and receive cycles in order to implement simultaneous multiple-beams, conformal array beamforming, array pattern synthesis, and neural beamforming.

(U) In FY 2005: Evaluate Digital Beamforming on both transmit and receive cycles in order to implement simultaneous multiple-beams, conformal array beamforming, array pattern synthesis, and neural beamforming.

(U) Total Cost							0.000	1.056	1.406

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) PE 0602204F, Aerospace Sensors.									
(U) PE 0603203F, Advanced Aerospace Sensors.									
(U) PE 0603500F, Multi-Disciplinary Adv Dev Space Technology.									
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2004

BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602500F MULTI-DISCIPLINARY SPACE TECH

PROJECT NUMBER AND TITLE: 5082 Optical Networking Tech

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5082 Optical Networking Tech	0.000	6.065	4.920	4.889	4.878	4.865	4.853	0.000	0.000
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2004, in Project 5082, the Air Force increased emphasis on developing optical networks for space-based applications.

(U) A. Mission Description and Budget Item Justification

This project develops the technology base for the next generation of ultra-wide- bandwidth, multi-channeled, space-based communications networks on and between platforms. As the application of laser-based, point-to-point communications between satellites emerges, space-based optical networks, whose communications capacities are thousands of times greater than current communications satellites, become a realistic possibility. A major thrust of this project is to assess and adapt the emerging communication and information technologies, being developed for next-generation Internet, for applications in space. This project will explore technologies for implementing photonic chip scale optical Code Division Multiple Access (CDMA) and Wavelength Division Multiplexed (WDM) transceivers and prototype networks, built to demonstrate the benefits associated with the advanced fiber optic, wireless, and satellite networks that can be built from them. This technology has potential applications in specific military systems including reliable, high bandwidth, jam-resistant communications at the theater level, and multiplexing of multiple DoD users onto a common networking infrastructure for reduced manning and logistics.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop and assess optical network technologies for application in the space environment.	0.000	1.989	1.932
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Assess, explore, and adapt the emerging communication and information technologies being developed for next-generation Internet, for applications in space.			
(U) In FY 2005: Complete assessment of next generation Internet arrayed-waveguide grating technologies for application in the space environment. Initiate design and development of a multi-path interconnection network that provides for redundancy, fault tolerance, self-routing and non-blocking switching required for space-based networks. Develop heterogeneous, seamless, secure, self-configuring high capacity network technologies and study their applicability to integrated Air, Space, Ground Networks Supporting Network Centric Operations. Develop variable data rate, networked data link radio frequency/optical hardware and their associated ground stations. Develop transmission technology and control concepts to support optically networked communications.			
(U)			
(U) MAJOR THRUST: Develop and assess existing and emerging Optical Code Division Multiple Access and Wavelength Division Multiplexed modulation schemes and protocols for use in space-based optical networks.	0.000	2.061	2.002
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: In conjunction with industry and academia, develop or adapt appropriate standards to ensure the evolution of open systems architecture for space-based optical networks.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **02 Applied Research**	PE NUMBER AND TITLE **0602500F MULTI-DISCIPLINARY SPACE TECH**	PROJECT NUMBER AND TITLE **5082 Optical Networking Tech**

(U)	In FY 2005: Develop or adapt, along with industry and academia, appropriate standards to ensure the evolution of open systems architecture for space-based optical networks. Investigate emerging terrestrial optical burst switching and optical label switching protocols for applicability to space-based optical networks.			
(U)				
(U)	MAJOR THRUST/CONGRESSIONAL ADD: Establish and maintain a capability to characterize, evaluate, and optimize network components and technologies for space applications. Note: In FY 2004, Congress added $1.0 million for Photonics Technology.	0.000	2.015	0.986
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Develop photonic chip scale optically implemented Code Division Multiple Access (CDMA) and Wavelength Division Multiplexed (WMD) transceivers and laboratory network into a capability to characterize, evaluate, and optimize optical network components and technologies for space applications.			
(U)	In FY 2005: Develop and evaluate performance of passive and active optical/electronic chip-scale networking components (transmitters, receivers, switches) for CDMA and WMD on board networks operating at gigabits per second.			
(U)	Total Cost	0.000	6.065	4.920

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) PE 0602702F, Command, Control, and Communications.									
(U) PE 0603789F, C3I Advanced Development.									
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.									

(U) D. Acquisition Strategy

Not Applicable.