PE NUMBER: 0602601F
PE TITLE: Space Technology

Exhibit R-2, RDT&E Budget Item Justification

DATE: February 2006

BUDGET ACTIVITY: 02 Applied Research

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	Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
	Total Program Element (PE) Cost	102.928	104.392	85.594	114.195	129.471	127.847	129.358	Continuing	TBD
1010	Space Survivability & Surveillance	51.965	46.216	44.254	44.917	48.115	49.677	50.198	Continuing	TBD
4846	Spacecraft Payload Technologies	17.054	15.912	15.119	24.988	30.422	29.475	29.906	Continuing	TBD
5018	Spacecraft Protection Technology	2.497	2.367	1.938	2.379	2.516	2.551	2.579	Continuing	TBD
8809	Spacecraft Vehicle Technologies	31.412	39.897	24.283	41.911	48.418	46.144	46.675	Continuing	TBD

Note: Funds for the FY 2006 Congressionally-directed Lightweight Photovoltaic Electricity and Hydrogen for Portable, On-Demand Power for Defense Applications in the amount of $1.0 million are in the process of being moved to this PE from PE 0602203F, Aerospace Power Technology, Project 3145, for execution.

(U) A. Mission Description and Budget Item Justification

This PE focuses on four major areas. First, space environmental protection develops technologies to understand, mitigate, and exploit effects of weather and geophysics environments on the design and operation of Air Force systems. Second, spacecraft payload technologies improve satellite payload operations by investigating advanced component and subsystem capabilities. Third, spacecraft protection develops technologies for protecting U.S. space assets in potential hostile settings. The last major area, spacecraft vehicles, focuses on spacecraft platform, payload, and control technologies, and their interactions. Note: In FY 2006, Congress added $1.5 million for Consortium for Autonomous Satellite Systems, $2.5 million for Integrated Control for Autonomous Space Systems (ICASS), $2.4 million for Nano-reinforced Structures and Advanced Multi-functional Structures for Space Programs, $2.0 million for Large Aperture Deployable Structure Systems for Space, $1.5 million for Elastic Memory Composites, $4.4 million for Converted Silicon Carbide for High Performance Optic Structures, $3.4 million for High-frequency Active Auroral Research Program (HAARP), $2.3 million for Deployable Structures Experiment, and $1.4 million for National Security Research--Signature Exploitation. This program is in Budget Activity 2, Applied Research, since it develops and determines the technical feasibility and military utility of evolutionary and revolutionary space technologies.

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

		FY 2005	FY 2006	FY 2007
(U)	Previous President's Budget	107.419	84.540	92.178
(U)	Current PBR/President's Budget	102.928	104.392	85.594
(U)	Total Adjustments	-4.491	19.852	
(U)	Congressional Program Reductions	0.000	-0.038	
	Congressional Rescissions	-0.108	-1.510	
	Congressional Increases	0.000	21.400	
	Reprogrammings	-2.845		
	SBIR/STTR Transfer	-1.538		

(U) Significant Program Changes:

Changes to this PE since the Previous President's Budget are due to higher Air Force priorities.

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C. Performance Metrics
(U) Under Development.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2006
BUDGET ACTIVITY: 02 Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology	PROJECT NUMBER AND TITLE: 1010 Space Survivability & Surveillance	

Cost ($ in Millions)		FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
1010	Space Survivability & Surveillance	51.965	46.216	44.254	44.917	48.115	49.677	50.198	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

This project develops the technologies to exploit the space environment for warfighter's future capabilities. The project focuses on characterizing and forecasting the battlespace environment for realistic space system design, modeling, and simulation, as well as the battlespace environment's effect on space systems' performance. It includes technologies to specify and forecast the environment from "mud to sun" for planning operations and ensuring uninterrupted system performance, optimize space-based surveillance operations, and allow the opportunity to mitigate or exploit the space environment for both offensive and defensive operations. Finally, this project includes the seismic research program that supports national requirements for monitoring nuclear explosions.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Develop technologies for specifying, monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense (DoD) operational space systems in order to improve performance, reduce cost, and increase operational lifetimes.	3.936	4.104	5.054

(U) In FY 2005: Upgraded initial version of dynamic radiation belt specification and forecast model to include extreme solar shock events responsible for the worst radiation conditions. Completed conceptual design of advanced, high-resolution solar telescope and conducted initial and critical design of next-generation solar hazard forecasting tool. Tested novel concepts to detect high-energy space particles using micro- and nano-technology based sensors suitable for inclusion in microsatellite constellations to specify space weather. Conducted initial building empirical solar flare forecast algorithms and developed initial physics based modeling to improve accuracy and lead-times for prediction of debilitating explosive events.

(U) In FY 2006: Initiate development of multi-sensor global data assimilation models for real-time situational awareness of energetic electron hazards to space systems. Validate dynamic radiation belt specification and forecast model with data from geosynchronous and low-Earth orbit DoD satellites. Complete physical design and accomplish Preliminary Program Design Review of next generation, high-resolution solar telescope. Develop autonomous procedures to cross calibrate, quality control, and validate solar magnetic field data from disparate network of ground-based telescopes for use in kinematic and hybrid solar wind models. Complete analysis of promising micro- and nano-technology space plasma and energetic particle sensor concepts and transition into spaceflight hardware development programs.

(U) In FY 2007: Continue development of energetic electron data assimilation models for real-time situational awareness by coupling to dynamic radiation belt model to provide data-driven specification and forecast capability. Initiate coupling of radiation belt model to global geospace environment models to increase accuracy and lead time.

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)	Complete initial predictive model of solar explosive events, including flares, bursts, and coronal mass ejections. Develop concepts for active beam and wave probes of radiation belt dynamics.			
(U)				
(U)	MAJOR THRUST: Develop spectral signature libraries, target detection techniques, and decision aids for application to space-based surveillance, laser weapons, and countermeasure systems, including detection of low-observable targets, and targets and space-based resident space object characterization. Note: In FY 2007, there is an increased emphasis on low-observable target detection.	12.478	13.883	17.088
(U)	In FY 2005: Validated and delivered all-altitude, infrared background radiance model for extended radiance sources and conducted initial analysis of existing infrared observations from space of resident space objects. Upgraded and improved atmospheric turbulence models for use in decision aids for tactical high-energy laser systems. Improved turbulence forecast technology for a turbulence decision aid for high altitude air vehicles. Developed advanced on-chip digital signal processing technologies for real-time hypertemporal detection. Validated day/night spectral exploitation algorithms and related signature databases for specific environments such as littoral, agricultural, desert, and woodlands. Used validated simulations to evaluate candidate technologies for spectral theater surveillance and area search missions.			
(U)	In FY 2006: Develop technologies for visible to infrared wavelength sensing for space-to-space resident space object characterization. Using available airborne and spaceborne data, validate daytime spectral processing algorithms and related signature databases for remaining terrain classes. Use test data and validated simulations to evaluate candidate sensor technologies for spectral theater surveillance and area search missions. Develop real-time hypertemporal processing algorithms and determine optimal parameters for operational system. Improve turbulence forecasting skill, as required, and assist in transition of airborne laser decision aid for testing to operational decision aid status. Perform case studies on existing and improved stratospheric clear air turbulence forecast tools. Address decision aid requirements for tactical high-energy lasers and laser communication systems.			
(U)	In FY 2007: Demonstrate technologies for space-based detection, identification and characterization of for resident space object characterization, environmental monitoring, and missile warning/defense. Develop super-resolution techniques for space-based resident space objects for space situational awareness. Initiate transition of validated spectral processing and exploitation algorithms and related signature databases to appropriate users. With available thermal spectral sensors, validate nighttime spectral processing algorithms and related signature databases for specific environments. Initiate transfer of sensor technologies and architecture concepts to acquisition and operational commands as appropriate. Refine real-time hypertemporal processing algorithms; and continue determination of optimal parameters for operational system. Develop third generation (model) hypertemporal sensor for space. Initiate transition of improved stratospheric clear air turbulence forecast models to Air Force Weather			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
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	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	Agency. Continue to address technology requirements for transition of operational decision aids for airborne lasers, tactical high-energy laser systems, and laser communication systems.			
(U)				
(U)	MAJOR THRUST: Develop artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including communications/navigation outage forecasting (C/NOFS), space-based geolocation demonstrations, and determination and prediction of radar degradation.	6.501	6.649	5.459
(U)	In FY 2005: Generated communication/navigation outage nowcasts and forecasts due to ionospheric scintillation to give the warfighter improved battlefield situational awareness and operational flexibility. Developed validated ionospheric specification and forecast models and products using results from military evaluation of the C/NOFS Advanced Concept Technology Demonstration (ACTD). Investigated ionospheric scintillation technologies to develop techniques for longer-term outage forecasting. Completed pole-to-equator scintillation specification model giving global real-time hazard alerts. Coupled magnetospheric data assimilation and forecast models to validated ionospheric electron profile models to improve geolocation accuracy and increase forecast lead times for radar operations. Developed combined laboratory/field tests to demonstrate feasibility of receiver and transmitter technologies to mitigate hazardous scintillation conditions.			
(U)	In FY 2006: Generate nowcasts and forecasts of communication/navigation outages due to ionospheric scintillation using C/NOFS space and ground system to give the warfighter improved space and battlefield awareness and operational flexibility. Perform metric tests making standardized comparisons between C/NOFS forecast model and product output parameters and selected available measurements to assess effectiveness of scintillation forecasting process. Develop statistical database and tools to track C/NOFS forecast metrics to assess military utility of outage warning due to scintillation. Develop technology to produce artificial ionization patches for use in over-the-horizon radar/comm applications and to mitigate scintillation conditions. Develop specification and forecast models and applications that exploit international network of ionospheric sensors.			
(U)	In FY 2007: Perform metric tests of C/NOFS scintillation forecasting system. Integrate C/NOFS results into ionospheric specification and forecasting algorithms and models for enhanced military utility of scintillation warning system. Investigate coupled solar-magnetospheric-ionospheric-thermospheric models to improve forecast lead times for radar operations, and communications/navigation outages. Develop portable ionospheric sensor suite for measuring total electron content and communications/navigation scintillation.			
(U)				
(U)	MAJOR THRUST: Develop High-frequency Active Auroral Research Program site transmitting and diagnostic instrument infrastructure.	10.588	10.000	9.757
(U)	In FY 2005: Populated the high frequency transmitter array to its full capacity of 180 array elements and 3.6			

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(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
megawatt radiated output power.			
(U) In FY 2006: Complete 180-element high frequency transmitter array with 3.6 megawatt radiated power capacity.			
(U) In FY 2007: Validate performance of 3.6 megawatt transmitting array in Extremely Low Frequency/Very Low Frequency (ELF/VLF) wave generation and optical emissions research programs.			
(U)			
(U) MAJOR THRUST: Develop basic seismic technologies to support national requirements for monitoring nuclear explosions with special focus on regional distances less than 2,000 kilometers from the sensors.	6.551	6.849	6.896
(U) In FY 2005: Provided updated seismic codes for operational use. Researched efforts on seismic energy partition (shifting focus towards in situ measurements below the source), magnitudes, and source physics; seismic calibration; seismic detection, location, and discrimination; and observational studies of seismic wave propagation, including propagation in Eurasia. Assessed future direction of seismic research based on results obtained so far and conducted seismic research on these and other topics of interest to the Air Force.			
(U) In FY 2006: Provide further updated seismic codes for operational use. Focus on seismic energy partition, magnitudes, and source physics moves from hypothesis development towards major hypothesis flyoff. Continue efforts on seismic calibration; seismic detection, location, and discrimination; and observational studies of seismic wave propagation, including propagation in Eurasia. Initiate focus on transition between local and regional seismic wave propagation and implications for all topics above. Continue assessment future directions based on results obtained so far.			
(U) In FY 2007: Continue to update seismic codes for operational use. Develop hypothesis test results into potential discrimination and yield estimation techniques, while addressing unresolved hypothesis issues for seismic energy partition, magnitudes, and source physics. Incorporate seismic energy partition effects into implications for local and regional seismic wave propagation. Continue efforts on seismic calibration; seismic detection, location, and discrimination; and observational studies of seismic wave propagation, including propagation in Eurasia. Continue assessment future directions based on results obtained so far.			
(U)			
(U) CONGRESSIONAL ADD: High-frequency Active Auroral Research Program (HAARP).	5.370	3.351	0.000
(U) In FY 2005: Developed Ultra High Frequency radar and optical diagnostic infrastructure at the HAARP site. Provided facility management and environmental oversight functions. Conducted research programs to develop key engineering parameters related to exploiting ELF/VLF waves generated in space for subsurface communications, the imaging of underground structures, and the reduction of charged particle concentrations in the earth's radiation belts.			
(U) In FY 2006: Conduct Congressionally-directed effort for HAARP.			
(U) In FY 2007: Not Applicable.			

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)				
(U)	CONGRESSIONAL ADD: Electromagnetic Gradiometer (EM) Gradiometer for the Detection and Confirmation of Underground Hiding Places & Passageways.	2.733	0.000	0.000
(U)	In FY 2005: Developed covert man portable hardware system using remote Very Low Frequency illumination. Assessed the viability of a small, low-flying Unmanned Aerial Vehicle based system using a higher frequency local illuminator for detection of detonation wires on Improvised Explosive Devices. Conducted initial development of demonstration system for unmanned, randomly distributed array and explored preliminary field-testing of system concept.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Seismic Monitoring Program.	2.733	0.000	0.000
(U)	In FY 2005: Performed academic and industry research that will enable operational monitoring of high priority areas of U.S. national concern that would be otherwise inadequately monitored in the near-term. This research supports the Air Force Technical Application Center mission of global nuclear explosion monitoring.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: USAF Center for National Security Research - Signature Exploitation/National Security Research - Signature Exploitation.	1.075	1.380	0.000
(U)	In FY 2005: Developed engineering model smart single detectors and small smart detector arrays with very large dynamic range, broad range of integration times, very large frame rates, local data storage, and in-line processing for each detector element. Ground tests were done on the first generation.			
(U)	In FY 2006: Conduct Congressionally-directed effort for National Security Research - Signature Exploitation.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	51.965	46.216	44.254

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

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0305111F, Weather Systems.									

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

(U) PE 0305160F, Defense Meteorological Satellite Program.

(U) PE 0601102F, Defense Research Sciences.

(U) PE 0602204F, Aerospace Sensors.

(U) PE 0603401F, Advanced Spacecraft 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 2006
BUDGET ACTIVITY: 02 Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology	PROJECT NUMBER AND TITLE: 4846 Spacecraft Payload Technologies	

Cost ($ in Millions)		FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
4846	Spacecraft Payload Technologies	17.054	15.912	15.119	24.988	30.422	29.475	29.906	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: In FY 2006, decrease in funding is due to higher Air Force priorities.

(U) A. Mission Description and Budget Item Justification

This project develops advanced technologies that enhance spacecraft payload operations by improving component and subsystem capabilities. The project focuses on four primary areas: (1) development of advanced, space-qualified, survivable electronics, and electronics packaging technologies; (2) development of advanced space data generation and exploitation technologies, including infrared, Fourier Transform hyperspectral imaging, polarimetric sensing, and satellite antenna subsystem technologies; (3) development of high-fidelity space simulation models that support space-based surveillance and space asset protection research and development for the warfighter; and (4) development of advanced networking, radio frequency, and laser communications technologies to support next generation satellite communication systems.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Develop advanced infrared device technologies for space applications that enable hardened space detector arrays with improved detection, to perform acquisition, tracking, and discrimination of space objects such as decoys, satellites, and warheads throughout their trajectory.	3.553	3.636	3.317

(U) In FY 2005: Incorporated design changes into the fabrication process and advanced wafer growth of strained-layer superlattice detector structures and other promising technologies. Investigated wafer growth of strained-layer superlattice detector structures and other promising technologies as alternatives to mercury cadmium telluride developing both improved performance at a given operating temperature and comparable performance at higher operating temperatures. Evaluated promising "on-focal plane array (FPA)" polarimetric concepts developed to meet projected capability requirements of the next generation space systems. Investigated wavelength agility in detectors. Extended investigation of proton-damage in long wavelength infrared focal plane arrays in the space-relative environment.

(U) In FY 2006: Continue studies in metal films. Demonstrate two-layer single-pixel polarimeter. Improve quantum dot detector responsivity. Continue characterizing superlattice detectors. Continue investigating magnetic and electric field tuning of detector wavelength responsivity ("wavelength agility"). Perform comparisons of emerging detector technologies for transfer to applied research. Characterize and assess performance of long wavelength infrared focal plane arrays developed with radiation hardened-by-design process.

(U) In FY 2007: Pursue detector response tunability. Complete assessment of quantum interference towards amplification of incoming weak signals. Study radiation damage of very long wavelength and visible FPAs.

(U)

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)	MAJOR THRUST: Develop spectral sensing and data exploitation methodologies for military imaging and remote sensing applications.	0.790	0.987	0.899
(U)	In FY 2005: Completed assessment and documentation of electro-optical/infrared spectral polarimetric phenomenology understanding. Demonstrated validated polarimetric signature model capability and developed new code upgrades and validation with measured data from on-going field collections. Demonstrated integration of spectral polarimetric models into scene simulation architecture for space-based surveillance applications.			
(U)	In FY 2006: Complete development and continue validation of polarimetric scene modeling capability for space-based surveillance applications. Integrate additional models for accurate prediction of satellite materials signatures and compare with available laboratory and field data. Complete development of instrument models for staring polarimetric surveillance systems. Develop polarimetric and spectral measurement and database of relevant materials for inclusion in the model.			
(U)	In FY 2007: Complete validation of polarimetric scene and signature modeling capability, comparing simulated data to measured field data. Complete initial polarimetric database of materials for use in signature and scene modeling. Define concepts for polarimetric or multi-band imaging sensors for space-based space surveillance applications.			
(U)				
(U)	MAJOR THRUST: Develop technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, micro-electro-mechanical system devices, and advanced electronics packaging for next generation high performance space electronics.	3.501	3.726	3.472
(U)	In FY 2005: Researched radiation effects in electronics built with hardness-by-design methods at state-of-the-art manufacturing plants. Evaluated chalcogenide-based reconfigurable electronics providing ten-fold performance improvement and self-repair capabilities. Built monolithically integrated low-power, silicon-based quantum-sized devices for system-on-a-chip applications. Established tools for hardness-by-design part manufacture and demonstrated ten-fold decrease in manufacturing cost. Designed switches on chip, board, and intra-board level supporting self-adaptable, self-healing spacecraft hardware. Developed and evaluated architectures and packaging approaches in support of reconfigurable space systems.			
(U)	In FY 2006: Design new chalcogenide materials for reconfigurable radio frequency (RF) circuits and for reconfigurable wiring. Develop fundamental understanding of exotic high-dielectric constant materials and predict candidate materials for insertion into aggressively scaled electronic devices for space electronics. Research radiation effects in highly integrated microelectronics employing the most recent techniques in power management, clock domain partitioning, and monolithic integration of multiple radio frequency, analog, and digital functions. Identify and evaluate radiation hardening techniques for enhancing immunity to single event and other radiation effects arising from the natural space environment, as well as nuclear events. Develop a "liquid manifold" approach based			

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	on combining micro-electromechanical switches and reconfigurable wiring and demonstrate operation.			
(U)	In FY 2007: Complete study of dynamics of phase change materials, and of their interactions with pertinent technological materials. Explore use of polymers in reconfigurable electronics. Continue study of alternative dielectrics for advanced electronics, especially the nitrided oxides. Initiate a nanotechnology collaboration with the Air Force Research Laboratory Materials Directorate. Research radiation effects mitigation schemes using best commercial practices in design and manufacturing to identify new methods for creating radiation hardened, long-lifetime, commodity and custom mixed signal microcircuits for next generation space and missile systems. Evaluate devices using advanced hardening techniques to determine robustness and compatibility with state of the art design and fabrication technology. Develop morphable electronic panels suitable for demonstration in a relevant environment.			
(U)				
(U)	MAJOR THRUST: Develop modeling, simulation, and analysis tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, distributed satellite architecture, and space control payloads.	2.912	2.441	2.218
(U)	In FY 2005: Readied the simulation architecture to support flight experiment simulation and data validation for experiments on autonomous command/control software and responsive space technologies. Extended to the simulation architecture to address missions associated with responsive space, space capability protection, and counterspace. Develop enhancements to optical/infrared imaging system simulation to include polarimetric and hyperspectral effects.			
(U)	In FY 2006: Support autonomous and responsive space flight experiments with simulations and data validation. Extend the simulation architecture to feed engineering-level data to mission/campaign models. Extend the architecture to address missions associated with space situational awareness and tactical surveillance. Continue to develop enhancements to imaging system simulations to include polarimetric and hyperspectral effects. Tailor toolset and methodology developed for the multi-aperture strategic system feasibility study for tactical applications.			
(U)	In FY 2007: Continue to support autonomous and responsive space flight experiments with simulations and data validation. Continue to extend the simulation architecture to feed engineering-level data to mission/campaign models. Ready the simulation architecture to support flight experiment simulation and data validation for experiments on space situational awareness and tactical surveillance.			
(U)				
(U)	MAJOR THRUST: Develop bandwidth efficient modulation and high bandwidth communications technologies to support next generation satellite communication systems. Note: In FY 2006, efforts terminated due to higher Air Force priorities.	1.769	0.000	0.000

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	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)	In FY 2005: Further explored architecture studies and guide technology investment in support of satellite communications roadmap. Expanded development of technology standards and system designs for integrating multiple airborne intelligence, surveillance, and reconnaissance assets into single space platforms.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	MAJOR THRUST: Develop technologies for multi-access laser communications terminals. Assess the maturity of single access terminal components and their applicability to a multi-access terminal design.	4.529	5.122	5.213
(U)	In FY 2005: Developed standards for combining multiple airborne intelligence, surveillance, and reconnaissance and space asset feeds into a single optical data path. Designed laboratory multi-access terminal testbed.			
(U)	In FY 2006: Start verification of standards of combining multiple airborne intelligence, surveillance and reconnaissance and space asset feeds into a single optical data path. Perform component testing using laboratory testbed.			
(U)	In FY 2007: Finish verification of standards of multiple airborne intelligence, surveillance and reconnaissance and space asset feeds into a single optical data path. Perform system testing using laboratory testbed.			
(U)	Total Cost	17.054	15.912	15.119

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

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0603401F, Advanced Spacecraft 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

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BUDGET ACTIVITY: 02 Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

PROJECT NUMBER AND TITLE: 5018 Spacecraft Protection Technology

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
5018 Spacecraft Protection Technology	2.497	2.367	1.938	2.379	2.516	2.551	2.579	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

This project develops the technologies for protecting U.S. space assets in potential hostile environments to assure continued space system operation without performance loss in support of warfighter requirements. The project focuses on identifying and assessing spacecraft system vulnerabilities, developing threat warning technologies, and developing technologies to mitigate the effects of both intentional and unintentional threats.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Develop key satellite threat warning technologies and tools for high value satellite asset defense.	0.812	0.898	0.853
(U) In FY 2005: Updated micro-satellite threat characteristics. Selected most promising proximity sensor technology and initiate development of an experimental proximity sensor. Designed and developed ground demonstration plan for the purpose of confirming proximity sensor performance.			
(U) In FY 2006: Begin process of integrating most promising proximity or threat warning sensor into a space experiment. Identify potential of multiple usage of sensor to detect threats and measure environmental phenomenon associated with space flight (weather experiments, debris analysis, assist in navigation, etc.).			
(U) In FY 2007: Conduct sensor space flight experiment and analysis. Identify technology transfer opportunities and report findings to major commands.			
(U)			
(U) MAJOR THRUST: Develop high value space asset defensive capabilities.	0.538	0.588	0.552
(U) In FY 2005: Selected most promising defensive technologies and begin development of experimental defensive capabilities. Designed and reported ground and space demonstration plan for the purpose of confirming defensive capability performance.			
(U) In FY 2006: Select the most promising defensive technology and begin space experiment planning and integration. Identify potential of multiple use technology to detect threats and measure environmental phenomenon associated with space flight (weather experiments, analysis debris, assist in navigation, etc.).			
(U) In FY 2007: Conduct defensive technology space demonstration and post flight analysis. Identify technology transfer opportunities and report findings to major commands.			
(U)			
(U) MAJOR THRUST: Develop techniques to exploit existing on-board inherent satellite resources, satellite-as-a-sensor, and self-aware satellite technologies as a first-line threat detection system.	0.532	0.580	0.533
(U) In FY 2005: Conducted laboratory proof-of-concept for selected subsystems with ground simulation demonstration			

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(U) B. Accomplishments/Planned Program ($ in Millions)

		FY 2005	FY 2006	FY 2007
	of a combined satellite-as-a-sensor system. The simulation included data fusion, unique radio frequency location tool, simulated laser sensor, simulated proximity sensor, and satellite-as-a-sensor test bed.			
(U)	In FY 2006: Develop space experiment of existing cooperative onboard system or develop proof of concept space experiment to validate concept.			
(U)	In FY 2007: Transition technology to other compatible space systems for multiple use protection.			
(U)				
(U)	MAJOR THRUST: Develop techniques for monitoring and assessing electromagnetic interference and compatibility between ultra-sensitive payload sensors for space systems that support space weather forecasting. Note: Effort is complete in FY 2006.	0.615	0.301	0.000
(U)	In FY 2005: Performed measurements of key ionospheric and scintillation parameters needed for input to ionospheric specification and forecast models. Assessed data for electromagnetic interference effects on ultra-sensitive payload sensors.			
(U)	In FY 2006: Conduct space experiment demonstration of C/NOFS. Assess payload performance in measuring ionospheric and scintillation parameters needed for space weather support in theater and for mission planners and other users.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	2.497	2.367	1.938

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

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) PE 0603401F, Advanced Spacecraft 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 2006
BUDGET ACTIVITY: 02 Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology	PROJECT NUMBER AND TITLE: 8809 Spacecraft Vehicle Technologies	

Cost ($ in Millions)	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total
8809 Spacecraft Vehicle Technologies	31.412	39.897	24.283	41.911	48.418	46.144	46.675	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: Funds for the FY 2006 Congressionally-directed Lightweight Photovoltaic Electricity and Hydrogen for Portable, On-Demand Power for Defense Applications in the amount of $1.0 million are in the process of being moved to this PE from PE 0602203F, Aerospace Power Technology, Project 3145, for execution."

(U) A. Mission Description and Budget Item Justification

This project focuses on seven major space technology areas: spacecraft platforms (e.g., structures, controls, power, and thermal management); space-based payloads (e.g., survivable electronics); satellite control (e.g., software for autonomous distributed satellite formation flying, signal processing, and control); modeling and simulation of space-based systems; satellite protection technologies (e.g., space environment effects, debris prediction, and threat warning/attack reporting); microsatellite technologies; and space experiments of maturing technologies for space qualification.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U) MAJOR THRUST: Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts.	3.677	3.586	3.210
(U) In FY 2005: Built second-generation empirically verified thermo-physical performance models for cryocooler regenerators. Further investigated technology development to improve cryocooler capability and performance for regenerative and recuperative cycle cryocoolers. Build modeling and simulation capability for complex thermodynamic cycle coolers. Developed a 30% efficient crystalline multi-junction solar cell based on lattice-mismatch technology. Fabricated 10% efficient thin-film, monolithically integrated solar cell.			
(U) In FY 2006: Build experimental capabilities for flow field measurements in pulse tube cryocoolers. Refine and validate cryocooler component and system models with experimental data. Investigate thermodynamic loss mechanisms in regenerative cycle cryocoolers through computational fluid dynamics models. Demonstrate 12% efficient thin-film solar cell on polymer substrate. Demonstrate five- or six- junction solar cell.			
(U) In FY 2007: Develop component-based system model of pulse tube cryocoolers for parametric optimization of cryocooler system design. Design an ultra low-temperature (10 degrees Kelvin), low mass and high efficiency advanced engineering model cryocooler. Transition optimal design methodologies to cryocooler industry. Demonstrate greater than 33% efficient solar cell using either lattice mismatch or five- or six- junction solar cell technology. Develop a greater than 12% efficient thin-film solar cell on a polymer substrate at least 20 square centimeters in area.			
(U)			
(U) MAJOR THRUST: Develop technologies for advanced space platform structures such as structural controls for vibration suppression, multi-functional structures, deployable large aperture optical arrays, and lightweight	6.488	6.365	5.759

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT NUMBER AND TITLE 8809 Spacecraft Vehicle Technologies

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
composite satellite and launch vehicle structures.			
(U) In FY 2005: Performed material characterization of tunable nanotechnology-enhanced lightweight space structures. Fabricated and tested engineering concepts for lightweight structures and precision structural controls for large-aperture space optics. Fabricated and tested low-shock and precision deployment mechanisms for satellite separation and subsystem deployment.			
(U) In FY 2006: Develop advanced mechanisms and guidance strategies for capture and servicing of disabled (non-cooperative) spacecraft. Develop high-temperature, long-soak time thermal re-entry structures.			
(U) In FY 2007: Characterize thermal protection structural performance in reentry environment. Develop autonomy concepts to support defensive/protection actions by spacecraft.			
(U)			
(U) MAJOR THRUST: Develop microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. The innovative microsatellite architectures and advanced satellite bus technologies could enable applications such as space protection, counterspace capabilities, sparse aperture sensing, on-orbit formation flying, inter-satellite communications, distributed processing, and responsive payloads. Note: In FY 2006, efforts move to Project 4846 in this PE and to PE 0603401F, Project 2181.	1.013	0.000	0.000
(U) In FY 2005: Completed evaluation of the technical feasibility and cost-effectiveness of a multi-aperture system to meet future space-based radio frequency intelligence, surveillance and reconnaissance needs.			
(U) In FY 2006: Not Applicable.			
(U) In FY 2007: Not Applicable.			
(U)			
(U) MAJOR THRUST: Develop flight experiments to address key scientific and technological problems in order to improve the capabilties of existing operational space systems and to enable new transformational space capabilities: Note: In FY 2005, reduction is due to higher Air Force priorities.	9.106	13.583	15.314
(U)			
(U) In FY 2005: Matured space flight experiment design. Developed breadboard hardware for most experimental payloads. Initiated fabrication of core spacecraft flight structure. Closed design trades and advanced all designs to a Preliminary Design Review level. Designed interfaces to launch vehicle and co-manifested spacecraft needed to secure launch manifest. Performed modeling and simulation to quantify benefit to DoD warfighter capability.			
(U) In FY 2006: Complete fabrication of spacecraft structure. Build and test core spacecraft and experimental payloads. Complete mission planning and on-orbit operations guide. Complete spacecraft system Preliminary Design Review to freeze all interfaces. Advance design to level needed for Critical Design Review.			
(U) In FY 2007: Complete Critical design Review for all payloads to freeze all designs and authorize fabrication of all			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT NUMBER AND TITLE 8809 Spacecraft Vehicle Technologies

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	flight hardware. Complete fabrication of integrated spacecraft core including structure and electronics. Initiate delivery of individual experiment payloads and begin assembly, integration, and test with the core spacecraft			
(U)				
(U)	CONGRESSIONAL ADD: Toughened Silicone Substrates for Flexible Solar Cells.	0.976	0.000	0.000
(U)	In FY 2005: Optimized free standing silicone resin substrates for solar cell deposition. Initiated monolithic integration process of Copper-Indium-Gallium-DiSelenide (CIGS) solar cells on silicone resin substrates. Completed initial performance optimization of CIGS solar cells deposited in roll-to-roll production on free standing silicone resin.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Integrated Control for Autonomous Space Systems (ICASS).	1.952	2.464	0.000
(U)	In FY 2005: Advanced the spacecraft system engineering to test and validate the advanced control techniques in a flight experiment. Fabricated breadboard models of spacecraft experimental computer system, networked data acquisition sensors, and networked data interface cards. Tested advanced attitude and dynamic control technologies on breadboard electronics. Closed design trades, initiated mechanical and electrical designs to Preliminary Design Review level.			
(U)	In FY 2006: Conduct Congressionally-directed effort for ICASS.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Elastic Memory Composites (EMC) and Elastic Memory Composites Materials.	1.953	1.479	0.000
(U)	In FY 2005: Improved the reliability of spacecraft deployment mechanisms. Raised the flight readiness of the EMC technology by generating material test data, creating and refining material models and engineering methods for designing EMC components, designing, fabricating, and testing structural validation models of EMC components, and performing a space flight demonstration to build flight heritage.			
(U)	In FY 2006: Conduct Congressionally-directed effort for Elastic Memory Composites.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Converted Silicon Carbide for High Performance Optic Structures.	1.463	4.337	0.000
(U)	In FY 2005: Applied the converted silicon carbide technology from FY 2004 efforts to Air Force systems currently under development. Identified products included the optical elements and support structure for a spaceborne optical system and optical support structures for an airborne directed energy system. Built specimens for integrated testing			

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT NUMBER AND TITLE 8809 Spacecraft Vehicle Technologies

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
	for potential optical space systems.			
(U)	In FY 2006: Conduct Congressionally-directed effort for Converted Silicon Carbide for High Performance Optic Structures.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Lightweight and Novel Structures for Space Program.	3.320	0.000	0.000
(U)	In FY 2005: Reviewed and examined new structures concepts that will enable revolutionary improvements on weight and cost of space structural systems. Identified the most promising concepts for further research and development.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Foldable Articulated Structures for Next Generation Spacecraft.	1.464	0.000	0.000
(U)	In FY 2005: Developed advanced space boom architectures and the mechanisms that enable them to be deployed in space and to enhance the performance of lightweight deployable structures for spacecraft. Verified flight readiness of this technology by performing the following: optimization of design of a family of deployable truss structural system; developed advanced analytical tools and quantitative design methods; performed design, fabrication, testing and qualitative assessment of the system; integration and flight readiness testing of the deployable structure and deployment control system.			
(U)	In FY 2006: Not Applicable.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Consortium for Autonomous Satellite Systems (CASS).	0.000	1.479	0.000
(U)	In FY 2005: Not Applicable.			
(U)	In FY 2006: Conduct Congressionally-directed effort for CASS.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Deployable Structures Experiment.	0.000	2.267	0.000
(U)	In FY 2005: Not Applicable.			
(U)	In FY 2006: Conduct Congressionally-directed effort for Deployable Structures Experiment.			
(U)	In FY 2007: Not Applicable.			
(U)				

Exhibit R-2a, RDT&E Project Justification		DATE February 2006
BUDGET ACTIVITY 02 Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT NUMBER AND TITLE 8809 Spacecraft Vehicle Technologies

	B. Accomplishments/Planned Program ($ in Millions)	FY 2005	FY 2006	FY 2007
(U)	CONGRESSIONAL ADD: Large Aperture Deployable Structure Systems for Space.	0.000	1.971	0.000
(U)	In FY 2005: Not Applicable.			
(U)	In FY 2006: Conduct Congressionally-directed effort for Large Aperture Deployable Structure Systems for Space.			
(U)	In FY 2007: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Nano-Reinforced Structures and Advanced Multi-Functional Structures for Space Programs.	0.000	2.366	0.000
(U)	In FY 2005: Not Applicable.			
(U)	In FY 2006: Conduct Congressionally-directed effort for Nano-Reinforced Structures and Advanced Multi-Functional Structures for Space Programs.			
(U)	In FY 2007: Not Applicable.			
(U)	Total Cost	31.412	39.897	24.283

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

	FY 2005 Actual	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 0602203F, Aerospace Propulsion.									
(U) PE 0602102F, Materials.									
(U) PE 0603311F, Ballistic Missile Technology.									
(U) PE 0603401F, Advanced Spacecraft Technology.									
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.									

(U) D. Acquisition Strategy

Not Applicable.