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

DATE: February 2003

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

	COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	79,330	76,239	83,240	90,810	92,771	100,742	122,044	129,729	Continuing	TBD
1010	Space Survivability & Surveillance	31,287	23,797	36,348	38,206	38,549	41,192	39,798	40,362	Continuing	TBD
4846	Spacecraft Payload Technologies	14,473	11,384	15,282	19,328	20,157	20,896	36,090	40,120	Continuing	TBD
5018	Spacecraft Protection Technology	0	4,346	4,045	2,831	2,653	2,500	2,567	2,635	Continuing	TBD
8809	Spacecraft Vehicle Technologies	33,570	36,712	27,565	30,445	31,412	36,154	43,589	46,612	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2003, Project 1010 is split, with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

This PE focuses on four major areas. First, space systems 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 environments. The last major area, spacecraft vehicles focuses on spacecraft platform, payload, and control technologies, and their interactions. Note: In FY 2003, Congress added $21.4 million ($5.1 million for the High-frequency Active Auroral Research Program (HAARP) Space Technology, $2.6 million for HAARP Incoherent Scatter Radar, $2.0 million for Electromagnetic Gradiometer Research, $3.0M for Seismic Monitoring Research, $1.4 million for Mixed Signal Very Large Scale Integrated (Circuits) for Space Vehicle Communication Subsystems, $3.0 million for TechSat 21, $1.4 million for Substrates for Solar Cells, $1.4 million for Integrated Control for Autonomous Space Systems, $1.0 million for Lightweight and Novel Structures for Space, and $0.5 million for Carbon Foam for Aircraft and Spacecraft).

(U) B. Budget Activity Justification

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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology

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

		FY 2002	FY 2003	FY 2004	Total Cost
(U)	Previous President's Budget	81,344	58,582	68,437	
(U)	Appropriated Value	81,686	79,942		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions	-342	-3,589		
	b. Small Business Innovative Research	-1,626			
	c. Omnibus or Other Above Threshold Reprogram		-114		
	d. Below Threshold Reprogram				
	e. Rescissions	-388			
(U)	Adjustments to Budget Years Since FY 2003 PBR		0	14,803	
(U)	Current Budget Submit/FY 2004 PBR	79,330	76,239	83,240	TBD

(U) Significant Program Changes:

Changes to this PE since the previous President's Budget are due primarily to higher priorities within the Science and Technology Program.

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

DATE: February 2003

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

PROJECT: 1010

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
1010 Space Survivability & Surveillance	31,287	23,797	36,348	38,206	38,549	41,192	39,798	40,362	Continuing	TBD

Note: In FY 2003, Project 1010 is split, with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

This project develops the technologies to exploit the space environment for the warfighter's benefit. 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) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $2,490 Developed technologies for monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense operational space systems. These technologies lead to improved space system design, lifetime operational capabilities, and aid in anomaly resolution. Used simulations to assess technologies that control hazardous space particle populations in extreme environments resulting from natural or adversarial actions. Used simulations and test data from space-based detector system to develop advanced algorithms for tracking system-impacting solar eruptions en route to Earth. Developed algorithms for short-term forecasting of solar flares based on observations of plasma flow in solar active regions. Validated time-dose probability codes for space system design using data from compact environment anomaly sensors. Completed design of space particle control experiment. Constructed dynamic radiation belt data assimilation and forecasted models to predict energetic electron spacecraft hazards.

(U) $8,070 Developed real-time infrared backgrounds clutter code, 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. Technologies lead to increased surveillance capability and to more effective operation of laser weapons and countermeasures systems. Developed global clutter specification model and dim-target detection techniques for advanced space-based surveillance systems. Incorporated global clutter model into all-altitude background prediction code and validated model with space-based data. Conducted field measurements to validate candidate concepts for earliest detection of theater ballistic missiles in boost phase. Tested and validated decision aids and performance prediction tools for turbulence effects on laser weapon system performance. Validated global spectral signature libraries created from collected hyperspectral imaging data, and developed a modeling and simulation capability to predict the performance of surveillance functions under specified scene and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 1010

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

atmospheric conditions.

(U) $7,010 Developed artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including communications/navigation outage forecasting and space-based geolocation demonstrations. This forecasting capability will support the warfighter through situational awareness, allowing operators to use alternate links or systems in times of outages. Integrated and validated the suite of ionospheric specification and forecast models for the Communications/Navigation Outage Forecast System (C/NOFS) Advanced Concept Technology Demonstration. Assembled the models with data-handling systems to construct the C/NOFS data center. Provided navigation reliability maps for geolocation requirements. Expanded the ground-based network of ultra high frequency and L-band satellite links to provide worldwide outage specification and enhance the ground-based component of C/NOFS. Established high latitude sites to monitor formation and motion of polar ionospheric patches.

(U) $1,356 Developed key satellite threat warning technologies and tools for on-board satellite use that detect, geolocate, and characterize acquired intentional and unintentional ground-based radio frequency and laser signals. Satellite threat warning technologies enable the warfighter to increase knowledge of possible hostile acts directed at mission critical satellites and aid in satellite anomaly resolution. Completed miniaturization of radio frequency attack reporting receiver. Investigated integrated attack reporting approaches.

(U) $8,209 Continued development of the High Frequency Active Auroral Research Program (HAARP) site transmitting and diagnostic instrument infrastructure. Installed a permanent aircraft alert radar, a Very High Frequency ionosphere radio diagnostic, high frequency transmitter enhancements, and diesel power-plant reliability improvements. Provided facility management and environmental oversight. Conducted research programs to assess the viability of exploiting Extremely Low Frequency/Very Low Frequency waves generated in the ionosphere for detecting and characterizing underground structures and for reducing charged particle populations in the radiation belts, which disrupt satellite systems and operations.

(U) $2,511 Developed a modular design and phased approach for an Incoherent Scatter Radar diagnostic capability for the HAARP facility. Prepared the site infrastructure, including a gravel pad, access road, and power and optical fiber distribution networks. Acquired and installed Incoherent Scatter Radar transmitting modules for engineering test purposes to validate the overall concept and design.

(U) $1,641 Investigated, enhanced, and tested electromagnetic radiometry technologies for the detection of underground structures using the HAARP facility. Developed a miniature, rugged man-portable hardware system and an experimental airborne system, including improved detection algorithms, frequency agility, and remote data access. Conducted a study for a ground-based, unmanned random array detection system to exploit emerging technology.

(U) $31,287 Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology
	PROJECT: 1010

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$1,283	Develop technologies for monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense (DoD) operational space systems. Validate algorithms for tracking solar plasma clouds to Earth and predicting onsets of adverse effects on DoD systems. Develop models and algorithms for propagation of solar/geomagnetic activity for spacecraft susceptibility to single event upsets. Complete initial dynamic radiation belt model with real-time data assimilation for spacecraft hazard forecasting.
(U)	$4,435	Develop real-time infrared backgrounds clutter code, 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. Validate background models with new experimental data and apply to surveillance system design trades and performance analyses. From field measurements determine trade space for space system for earliest detection of theater ballistic missiles in boost phase. Upgrade models of atmospheric turbulence sources and improve laser weapon performance prediction model of airborne and space-based systems. Develop advanced techniques to exploit hyperspectral data and validate hyperspectral performance modeling and simulation codes. Develop design requirements for space-based sensor to obtain sub-pixel, high spectral resolution measurements of optical/infrared backgrounds for next-generation operational surveillance, target identification, and damage assessment systems.
(U)	$5,509	Develop artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including communications/navigation outage forecasting and space-based geolocation demonstrations. Develop data processing software and hardware architecture for collecting and analyzing ground and space data to provide near-real-time nowcasts and forecasts of ionospheric hazards. Validate nowcast and forecast predictions using ground and space-based experimental databases and incorporate results into forecast tool risk reduction. Improve techniques to track the motion of the highly structured plasma in the polar region, to enhance the reliability of ionospheric specification in high latitude theaters. Develop multi-scale algorithms to increase reliability of global ionospheric forecasts.
(U)	$5,048	Continue development of the High-frequency Active Auroral Research Program (HAARP) site transmitting and diagnostic instrument infrastructure. Provide facility management and environmental oversight. Continue research programs to assess the viability of exploiting Extremely Low Frequency/Very Low Frequency waves generated in the ionosphere for military applications. Begin research programs to characterize high power radio wave interactions in the ionosphere and space, including the generation of irregularities and optical emissions and to exploit the HAARP diagnostic instruments for space weather specification. Develop real-time diagnostic and data analysis software and web displays.
(U)	$2,573	Develop a modular approach for installation of an Incoherent Scatter Radar (ISR) diagnostic at the HAARP facility. Complete site infrastructure for the ISR and preliminary support structure. Acquire and install a modular, 8-panel, ISR transmit/receive sub-array. Conduct a research program to characterize radio-wave interactions and processes in the ionosphere using the sub-array as a powerful radar diagnostic instrument in

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology
PROJECT: 1010	

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

conjunction with the High-frequency Active Auroral Research Program high power high frequency transmitting array.

(U) $1,979 Investigate, enhance, and test electromagnetic radiometry technologies for the detection of underground structures. Conduct field demonstrations of a miniature and rugged man-portable hardware system using Very Low Frequency waves to detect underground structures. Design a system with improved detection algorithms, frequency agility, and remote data access for unmanned aero vehicle/airborne applications. Develop techniques to enhance the operational viability of both the man-portable and airborne systems.

(U) $2,970 Develop seismic technologies to support national requirements for monitoring nuclear explosions. Enhance United States capabilities in seismic monitoring of nuclear explosions, with special focus on monitoring regional events located at distances less than 2,000 km from the sensors. Perform theoretical and experimental seismology studies to detect, locate, and characterize nuclear explosions.

(U) $23,797 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,226 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. Develop advanced space weather forecasting models combining remote sensing of interplanetary clouds with in situ plasma and fields data. Validate dynamic radiation belt model for satellite hazard forecasts with newly acquired data sets from operational DoD satellites. Develop advanced technology solar telescope for detecting and forecasting explosive solar events which generate spacecraft-damaging energetic particle events and initiate plasma clouds responsible for adverse communication and navigation effects. Develop capability to test sub-micron and nano-scale technology concepts for extremely small space hazard detectors.

(U) $9,965 Develop real-time infrared backgrounds clutter code, 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. Develop all-altitude, sub-pixel infrared background radiance model for atmospheric transmission of extended radiance sources such as missile hard bodies and plumes. Test and validate decision aids and turbulence performance prediction tools, including theater ballistic missile boost phase negation, on airborne laser platform. Expand models for other high energy laser systems and explore a forecasting capability for high altitude turbulence effects on aircraft platforms. Develop sensors, algorithms, and clutter removal techniques for space-based hypertemporal imaging sensor. Incorporate spectral signature variability into simulation codes to improve performance predictions. Collect high quality spectral data from existing systems and evaluate system requirements for theater surveillance and area search missions.

(U) $6,765 Develop artificial intelligence techniques, forecasting tools, and sensors for improved ionospheric specification and forecasting, including

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 1010

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

communications/navigation outage forecasting, space-based geolocation demonstrations, and determination and prediction of radar degradation. Develop nowcasting and forecasting validation algorithms for the Communication/Navigation Outage Forecasting System (C/NOFS) Advanced Concept Technology Demonstration. Integrate validation algorithms into ionospheric specification and forecast modeling architecture. Validate communication and navigation outage forecasts with C/NOFS satellite and ground-based data to demonstrate utility of outage warning due to scintillation. Integrate polar region plasma tracking models into global models of scintillation to provide seamless equator-to-pole outage specification. Validate multi-scale algorithms and data assimilation techniques to increase reliability of global ionospheric electron profile specifications and forecasts to improve radar and geolocation performance. Begin concept development of scintillation mitigation techniques to overcome satellite-to-ground link degradation in real-time.

(U) $9,767 Continue development of the High Frequency Active Auroral Research Program site transmitting and diagnostic instrument infrastructure. Provide facility management and environmental oversight. Initiate the completion of the high frequency transmitter array to its full capacity of 180 array elements and 3.6 megawatt radiated output power.

(U) $6,625 Develop basic seismic technologies to support national requirements for monitoring nuclear explosions. Enhance United States capabilities in seismic monitoring of nuclear explosions, with special focus on monitoring regional events located at distances less than 2,000 km from the sensors. Conduct seismic research such as seismic energy partitions for local and regional events, magnitudes and source physics; seismic calibration and ground truth collection; and seismic detection, location, and discrimination technologies. Perform observational studies of seismic wave propagation and collect seismic propagation characteristics of the Eurasian land-mass.

(U) $36,348 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0305160F, Defense Meteorological Satellite Program.
(U) PE 0601102F, Defense Research Sciences.
(U) PE 0602204F, Aerospace Sensors.
(U) PE 0305111F, Weather Systems.
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology
PROJECT: 1010	

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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

DATE: February 2003

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

PROJECT: 4846

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
4846	Spacecraft Payload Technologies	14,473	11,384	15,282	19,328	20,157	20,896	36,090	40,120	Continuing	TBD

(U) A. Mission Description

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) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,290 Developed advanced infrared device technologies for space applications that support hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of targets such as decoys, satellites, and warheads, throughout their trajectory. Developed cryogenic detector and read-out devices that will perform for extended periods of time under adverse natural and enhanced space environments. Developed and evaluated both broadband and narrow band detector devices and the appropriate low-noise, cryogenic read-out device and device architectures necessary for multi-band (two- and three-color) detection. Enhanced device architectures for future space sensor concepts that included the need for radiation-hardness, radiation tolerance, longer wavelengths, higher operating temperatures, and higher frame rates. Studied next generation detection requirements for space, and explored and exploited potential infrared device solutions.

(U) $993 Developed hyperspectral imaging data exploitation methodologies for military imaging and remote sensing applications. Fourier Transform HyperSpectral Imager (FTHSI) and polarimetric sensing technologies will provide enhanced surveillance capability for future space-based sensor systems by improving the ability of the systems to discriminate military targets in various scenarios. Completed evaluation of the hyperspectral imaging system performance based on data received from the FTHSI payload. Developed technology and modeling for understanding the electro-optical/infrared polarimetric phenomenology.

(U) $4,292 Developed technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, micro-electro-mechanical devices, and advanced electronics packaging for next generation high performance space electronics. Goals are decreased feature size, improved scalability, decreased size/weight/power, and radiation-hardness. Expanded microelectronic material characterization to silicon-on-insulator and chalcogenide materials and apply radiation research and material defect analysis to improve device

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology
PROJECT: 4846	

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		design. Fabricated and tested monolithically integrated low power, silicon-based quantum-sized devices. Characterized new radiation-hardened nonvolatile digital memories, Fast Fourier Transform (FFT) processors, and optical sensors. Investigated design enhancements for ten-fold performance improvement for the memories and FFT processors. Fabricated nonvolatile analog memories. Established a micro-electro-mechanical (MEMS) reliability test device for ground and space experiments. Investigated a chip-scale packaging system with optimized confinement features and coating for MEMS devices. Established a non-volatile analog reconfigurable packaging architecture.
(U)	$942	Developed modeling, simulation, and analysis (MS&A) tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, large deployable space optics, and distributed satellite architecture payloads. MS&A tools provide data to validate research and development systems engineering level technology trade off decisions for space-based missions/campaign level assessments and for intelligent satellite system test beds. Completed connection of satellite toolkit and spacecraft simulation toolkit. Extended simulation architecture to support flight software development and definition and conduct near-term flight test experiment.
(U)	$963	Developed advanced satellite antenna architectures and performance characterization tools for large, lightweight, modular space antennas. The advanced antenna architectures will improve the affordability and capability of antennas for space-based payload subsystems for Air Force surveillance and navigation efforts. Developed algorithms for performance characterization of modular phased-array antenna tiles. Built and tested engineering models to simulate performance of phased-array antenna tiles and integrated antenna modules. Characterized performance of antenna tiles and modules and correlate results to model predictions; updated models based on actual performance. Extended engineering models to simulate performance of the antenna tiles and integrated modules in a space environment in preparation for demonstration on a multi-microsatellite constellation space flight experiment.
(U)	$1,255	Developed core infrastructure components for a robust satellite simulation toolkit. The toolkit will enable cost-effective risk reduction for space technology programs via modeling and simulation of all phases from concept design through flight experiment and technology transition. Designed and built software components for different user interfaces, connection to external hardware/software environments and simulations, and installation on inexpensive computer platforms. Added models and simulations of such space-based payload systems as radar, hyperspectral, and remote inspection sensors. Developed requirements for and initial designs of high-level models of space capability protection and counterspace technologies to be used for concept studies.
(U)	$1,738	Developed radiation-hard analog circuit elements for mixed signal, Very Large Scale Integrated circuits for secure high-bandwidth intra-satellite and satellite-ground station communications. Radiation tested and characterized state-of-the-art commercial mixed signal systems and elements to determine feasibility of adapting commercial technologies for military application. Designed new radiation-hard analog elements.
(U)	$14,473	Total

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology	PROJECT: 4846

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$3,582	Develop advanced infrared device technologies for space applications that support hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of targets such as decoys, satellites, and warheads throughout their trajectory. Evaluate two- and three-color detector and continue development of multi-color detectors and tunable and broadband gratings. Design and fabricate selected concepts for future longer wavelength infrared detectors and infrared detectors with optimal background-limited performance for stressing, low photon noise, and space backgrounds. Complete design study of next generation long and very long wavelength infrared detector concepts, including quantum wells and strained layer superlattices, as lower cost, higher performance alternatives to mercury cadmium telluride. Evaluate delivered radiation-hardened cryogenic multiplexers for lower background, space infrared detector arrays.
(U)	$847	Develop spectral sensing and data exploitation methodologies for military imaging and remote sensing applications. Continue development of technology and modeling for understanding the electro-optical/infrared polarimetric phenomenology. Evaluate initial polarimetric signature model capability and validate with measured data. Develop capability to integrate polarimetric models into modeling, simulation, and analysis (MS&A) for space-based surveillance applications.
(U)	$3,511	Develop technologies for space-based payload components such as low power, high performance, radiation-hardened electronic devices, micro-electro-mechanical system (MEMS) devices, and advanced electronics packaging for next generation high performance space electronics. Continue silicon-on-insulator radiation research and enhance the switching speed and durability of the chalcogenide material by ten times for improved devices. Extend the design of the monolithically integrated low power, silicon-based quantum-sized devices to include non-traditional electronic materials. Continue to improve the speed of the radiation-hardened nonvolatile digital memories. Characterize the analog memories and enhance resolution to an eight-bit equivalent. Build space-qualified MEMS reliability test devices and chip-scale packages for ground and flight insertion. Build reconfigurable analog array packaging structures.
(U)	$1,118	Develop MS&A tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, and distributed satellite architecture payloads. Extend simulation architecture to support flight experiment ground-to-space segment simulation, post-experiment distributed signal processing, and post-experiment data validation. The architecture can then be used for objective system-of-systems assessment.
(U)	$941	Develop advanced satellite antenna architectures and performance characterization tools for large, lightweight, modular space antennas. Extend antenna architecture and algorithms developed for performance characterization of modular phased array antenna tiles to multi-beam, wider-bandwidth, multi-mode operation to support development of advanced low-power, low-noise amplifiers, integrated wide-bandwidth radiators, and active radio frequency manifold control technologies. Build a testbed to simulate performance of multi-beam, wide-bandwidth phased array antenna tiles and integrated antenna models.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology
PROJECT: 4846	

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

(U)	$1,385	Develop radiation-hard analog circuit elements for mixed signal, Very Large Scale Integrated circuits for secure high-bandwidth intra-satellite and satellite-ground station communications. Continue radiation testing and characterization of commercial state-of-the-art mixed signal components to determine the feasibility of employing commercial foundry technologies for space applications. Design and fabricate innovative circuit configurations and test devices using new radiation-hard analog elements and circuit architectures. Mixed signal designs will include analog to digital converters, frequency synthesizers, and phase locked loops.
(U)	$11,384	Total

(U) FY 2004 ($ in Thousands)

(U)	$0	Accomplishments/Planned Program
(U)	$2,865	Develop advanced infrared device technologies for space applications that support hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of targets such as decoys, satellites, and warheads throughout their trajectory. Fabricate and characterize strained-layer superlattice detectors and use results to modify designs to improve absorption efficiency and eliminate manufacturing or operationally induced defects. Complete the two-dimensional focal plane array development effort by identifying, designing, and fabricating the appropriate cryogenic detector multiplexors required for transitioning the technology. Begin development of infrared detector and detector read-out circuit technologies for next generation surveillance systems with projected requirements for adaptive, re-configurable, and polarimetric capabilities.
(U)	$759	Develop spectral sensing and data exploitation methodologies for military imaging and remote sensing applications. Complete initial assessment of technology and modeling for understanding the electro-optical/infrared spectral polarimetric phenomenology. Demonstrate partially validated polarimetric signature model capability and continue validation with measured data from ongoing field collects. Integrate initial polarimetric models into modeling, simulation, and analysis architecture for space-based surveillance applications.
(U)	$3,763	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. Research radiation effects in electronics components based on emerging silicon-on-insulator, sapphire, or other radio frequency and analog technology compatible substrates. Design new chalcogenide-based reconfigurable electronics providing ten-fold performance improvement based on adaptability. Demonstrate monolithically integrated low power, silicon-based quantum-sized devices for system-on-a-chip applications. Develop radiation hardening design techniques to enable fabrication of electronics on commercial lines. Demonstrate architecture and components supporting analog memory. Build micro-electro-mechanical system based switches supporting complex switching harnesses in support of self-adaptable spacecraft hardware. Develop architectures and packaging approaches in support of reconfigurable space systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 4846

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

(U)	$1,266	Develop modeling, simulation, and analysis tools for space-based surveillance systems, rendezvous and proximity operations, optical/infrared imaging space systems, and distributed satellite architecture payloads. Continue to extend simulation architecture to support flight experiment ground-to-space segment simulation, post-experiment distributed signal processing, and post-experiment data validation. Extend the architecture for use in objective system-of-systems assessment. Begin to develop extensions to the simulation architecture to address missions associated with space capability protection and counterspace. Begin to develop enhancements to optical/infrared imaging system simulation to include polarimetric effects.
(U)	$965	Develop advanced satellite antenna architectures and performance characterization tools for future large, lightweight, modular space antennas. Refine transmit/receive testbed, enhancing the performance of the phased-array antenna subsystems and integrated antenna modules using miniaturized active radio frequency components and planar wide-bandwidth radiators. Characterize performance of new wide-bandwidth antenna subsystems and correlate results to model predictions; update models based on actual performance. Develop algorithms for performance characterization of sparse cooperating apertures and for advanced antenna array calibration.
(U)	$1,888	Begin to develop bandwidth efficient modulation and high bandwidth communications technologies to support next generation satellite communication systems. Initiate architecture studies and guide technology investment in support of satellite communications roadmap. Begin development of technology standards and system designs for integrating multiple Airborne Intelligence, Surveillance, and Reconnaissance (AISR) assets into single space platforms.
(U)	$3,776	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. Begin development of standards for combining multiple AISR and space asset feeds into a single optical data path. Begin design of a laboratory multi-access terminal testbed.
(U)	$15,282	Total

(U) B. Project Change Summary

Not Applicable.

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

(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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology / PROJECT: 4846

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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

DATE: February 2003

BUDGET ACTIVITY: 02 - Applied Research

PE NUMBER AND TITLE: 0602601F Space Technology

PROJECT: 5018

COST ($ in Thousands)	FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
5018 Spacecraft Protection Technology	0	4,346	4,045	2,831	2,653	2,500	2,567	2,635	Continuing	TBD

Note: In FY 2003, Project 1010, is split with efforts focused on protecting spacecraft from manmade threats being transferred into Project 5018.

(U) A. Mission Description

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) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $0 No Activity

(U) $0 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $941 Develop key satellite threat warning technologies and tools for on-board satellite use to detect, geolocate, and characterize intentional and unintentional ground-based radio frequency (RF) and laser signals. Begin development of a high performance multiple threat sensors satellite protection system, improving technical performance of the sensor suite while still minimizing cost, power, and weight. Investigate integration of the miniature RF receiver, laser detector, and ionospheric specification system with advanced reconfigurable processor electronics for the first generation system. Assess feasibility of using a single antenna for performing RF geolocation from a low-earth-orbit satellite. Investigate laser and RF false alarm rejection/mitigation and anomaly resolution and management techniques.

(U) $1,312 Develop miniaturized RF attack receiver. Conduct risk reduction space shuttle experiment and perform post-test data and system performance analysis.

(U) $346 Develop techniques to exploit existing on-board satellite resources as first-line threat detection systems. Investigate use of systems on currently fielded or launch ready satellites for preliminary determination of RF/laser illumination or kinetic impact. Assess the use of telemetry, state-of-health data, and other appropriate data for event determination. Prepare for laboratory proof of concept demonstrations.

(U) $1,747 Develop techniques for monitoring and assessing electromagnetic interference and compatibility between ultra-sensitive payload sensors for space systems which support space weather forecasting. Begin payload integration for the Communications/Navigation Outage Forecast System Advanced Concept Technology Demonstration. Design, develop, and test serial communications hardware and software for command and data

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 5018

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

handling spacecraft sub-system risk reduction for real-time space weather forecasting. Validate data compression techniques with payload sensor data and apply to space flight software for demonstrating space weather forecasting.

(U) $4,346 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $1,296 Develop key satellite threat warning technologies and tools for on-board satellite use to detect, geolocate, and characterize intentional and unintentional ground-based radio frequency (RF) and laser signals. Develop and bench-test high performance multi-threat warning on-board sensors. Explore reconfigurable processor electronics capability and build testbed in support of multi-threat warning sensors. Analyze light, adaptable single antenna performance for threat detection and geolocation applications. Complete false alarm research for relevant threats. Select antenna technology for wide-band and narrow-band threat detectors for multi-threat capability space experiment.

(U) $854 Develop miniaturized RF attack receiver. Design and begin fabrication of miniaturized narrowband RF attack reporting receiver with of goal of five times reduction in power and size.

(U) $838 Develop techniques to exploit existing on-board satellite resources as first-line threat detection systems. Develop technology for currently fielded or launch-ready satellites to detect anomalies that result from RF/laser illumination or kinetic impact. Exploit on board resources such as telemetry or state-of-health data for anomaly determination as a zero added power/weight solution and assess the limits of this technique. Conduct laboratory proof of concept for selected subsystems.

(U) $1,057 Develop techniques for monitoring and assessing electromagnetic interference and compatibility between ultra-sensitive payload sensors for space systems which support space weather forecasting. Conduct space experiment demonstration of the Communication/Navigation Outage Forecasting System. Perform measurements of key ionospheric and scintillation parameters needed for input to ionospheric specification and forecast models. Assess data for electromagnetic interference effects on ultra-sensitive payload sensors. Assess payload performance in measuring ionospheric and scintillation parameters needed for space weather support in theater and for mission planners and other users.

(U) $4,045 Total

(U) B. Project Change Summary

Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology
PROJECT: 5018	

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

(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.

(U) E. Schedule Profile

(U) Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE: February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology / PROJECT: 8809

COST ($ in Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
8809	Spacecraft Vehicle Technologies	33,570	36,712	27,565	30,445	31,412	36,154	43,589	46,612	Continuing	TBD

(U) A. Mission Description

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 integrated experiments of advanced technologies for transition to planned systems (e.g., payload/platform/launch vehicle merging).

(U) FY 2002 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,265 Developed technologies for advanced space platform subsystems, such as cryocoolers, compact, high-efficiency solar power cells and arrays, and innovative power generation concepts. Advance space platform subsystems will have more available power, longer operational lifetimes and increased operational range, and will be lighter and more affordable than current subsystems. Continued identification of mechanical mechanisms for assessing cryocooler reliability. Developed improved models for low-temperature cryocooler regenerator performance. Completed a 32% efficient solar cell and a 10% efficient thin-film solar cell.

(U) $8,632 Developed technologies for advanced space platform structures such as structural controls for vibration suppression, multifunctional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Whole spacecraft launch vibration suppression will enable precision pointing and sensing systems. Multifunctional and composite structures, with a higher level of integration and standardized interfaces, will be reusable, lighter, and more affordable. Ground tested payload vibration suppression systems. Fabricated and characterized performance of multifunctional structure designs. Continued integration and ground test of component subsystems of deployable large aperture optical arrays. Started development of multifunctional bus structure for small spacecraft.

(U) $146 Completed development of ground support and small satellite integration technologies for spaceborne platforms with advanced bus components and standardized interfaces for testing and demonstrating revolutionary high payoff mission hardware and mission-enabling technologies for space and near-space experiments. Completed final analyses and reports on the MightySat II.1 platform and stand-alone experiment options.

(U) $15,988 Developed microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. Integrated and tested microsatellite engineering model, and began component fabrication of a three-unit flight constellation to demonstrate on-orbit formation flying, inter-satellite communications, distributed processing, and sparse aperture sensing.

(U) $2,898 Developed low-cost, lightweight, leak-proof, linerless, non-metallic composite cryogenic tanks for reusable and small expendable launch vehicle

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)		DATE February 2003
BUDGET ACTIVITY 02 - Applied Research	PE NUMBER AND TITLE 0602601F Space Technology	PROJECT 8809

(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

applications. Investigated novel composite material systems and processes, focusing on manufacturability and scaling. Developed liquid oxygen (LOX) compatible material system, addressing both oxidation and ignition phenomena. Designed, fabricated, and tested full-scale tanks to determine the effectiveness of microcrack mitigation and LOX compatibility techniques on flight-representative articles.

(U) $1,641 Developed and evaluated the world's first optically implemented Code Division Multiple Access wide-band network within the context of the Next Generation Internet. Continued to assess and demonstrate the inherent security capabilities of different coding schema as a means of enhancing information assurance at the transmission level.

(U) $33,570 Total

(U) FY 2003 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $4,409 Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts. Continue to improve accuracy of cryocooler modeling tools and the identification of mechanisms that limit operational life and degrade cryocooler subsystem performance. Demonstrate a 32% efficient solar cell. Demonstrate production capacity for a 10% efficient thin-film solar cell.

(U) $10,311 Develop technologies for advanced space platform structures such as structural controls for vibration suppression, multifunctional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Flight test payload vibration suppression systems. Continue performance characterization of multifunctional bus structure for small spacecraft.

(U) $14,805 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. Complete fabrication and qualification testing of microsatellite subsystem hardware for future flight demonstration of bus technologies, including advanced avionics, thin-film solar arrays, Hall Effect micro-thrusters, high density memories, and Lithium-polymer batteries.

(U) $2,970 Develop key microsatellite subsystem technologies to support mission applications that range from distributed aperture formations to space surveillance, threat warning, and protection. Build and functionally test flight hardware for the following advanced technology subsystems: high power density lithium polymer batteries, low power integrated Global Positioning System positioning and communications, lightweight thin-film solar arrays, and lightweight 160-Gbyte non-volatile mass memory.

(U) $1,385 Develop high temperature polymer substrates for thin film solar cells for next generation flexible, thin film solar arrays. These thin film arrays will be 3 to 5 times lighter, cost 5 times less, require 5 times less stowed volume, and be more radiation resistant than state-of-the-art rigid panel

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology / PROJECT: 8809

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

arrays. Current polymer substrates for Copper-Indium-Gallium-DiSelenide (CIGS) thin film solar cells do not survive the high temperature processing necessary for fabricating the highest efficiency solar cells. Develop, fabricate, and test high temperature silicone resin films suitable for CIGS thin film solar cell substrates. Demonstrate the deposition of CIGS solar cells on the high temperature polymers.

(U) $1,385 Develop advanced attitude and dynamic control technologies for next generation spacecraft. These technologies will provide unprecedented levels of control over dynamic subsystem response, precision pointing and target tracking. Design an integrated controls architecture which includes flight computer, an advanced suite of dynamic sensors, and real-time system identification software which can characterize the capability enhancements for operational space platforms.

(U) $991 Develop technologies for advanced mirror systems and space structures, including improved advanced mirror fabrication techniques and methods for enhancing performance of the associated structural systems required to support sensors in space. Current fabrication methods are labor and time intensive, and the product is heavy, expensive, and falls short of achieving technical requirements. Investigate non-traditional and innovative composite fabrication techniques, focusing on accelerated fabrication techniques and dimensionally stable materials.

(U) $456 Develop carbon foam-based structures for aircraft and spacecraft. Carbon foam based-structures will afford a critical 20% weight reduction without sacrificing structural performance. Investigate the performance requirements of structures for currently planned airborne and space-based systems and assess carbon foam blends and types for use in optical backing structures and the optical mounts for those systems. Downselect to the optimal carbon foam formulation and complete preliminary designs of an optical backing structure and optical mount.

(U) $36,712 Total

(U) FY 2004 ($ in Thousands)

(U) $0 Accomplishments/Planned Program

(U) $3,920 Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts. Complete identification of mechanical and long-term failure mechanisms for assessing cryocooler performance and reliability. Build first generation analytical performance prediction models, empirical measurements, and thermophysical fluid flow and heat transfer models for low-temperature cryocooler regenerator performance. Investigate technology development to improve cryocooler capability and performance for regenerative and recuperative cycle cryocoolers. Continue to demonstrate 32% efficient solar cells on reduced-mass wafers. Demonstrate 10% efficient thin-film solar cells on polymer substrate.

(U) $9,620 Develop technologies for advanced space platform structures such as structural controls for vibration suppression, multifunctional structures, deployable large aperture optical arrays, and lightweight composite satellite and launch vehicle structures. Complete characterization of multifunctional small spacecraft bus. Initiate development of tunable nanotechnology-enhanced lightweight space structures. Begin

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2A Exhibit)	DATE February 2003
BUDGET ACTIVITY: 02 - Applied Research	PE NUMBER AND TITLE: 0602601F Space Technology / PROJECT: 8809

(U) A. Mission Description Continued

(U) FY 2004 ($ in Thousands) Continued

development of lightweight structures and precision structural controls for large-aperture space optics. Begin development of low-shock and precision deployment mechanisms.

(U) $14,025 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. Integrate and functionally test microsatellite for future flight demonstration of bus technologies, including advanced avionics, thin-film solar arrays, Hall Effect micro-thrusters, high density memories, and Lithium-polymer batteries. .

(U) $27,565 Total

(U) B. Project Change Summary

Not Applicable.

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

(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) PE 0603500F, Multi-Disciplinary Advanced Development Space Technology
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.