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

DATE: February 2002

BUDGET ACTIVITY: 03 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

	COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
	Total Program Element (PE) Cost	61,171	60,932	42,315	53,323	54,364	61,987	63,206	Continuing	TBD
2181	Spacecraft Payloads	15,357	17,061	14,066	15,276	16,398	16,719	17,040	Continuing	TBD
3834	Integrated Space Technology Demonstrations	32,831	24,268	12,268	20,931	18,967	25,853	26,344	Continuing	TBD
4400	Space Systems Protection	5,302	6,050	2,798	3,075	3,545	3,617	3,685	Continuing	TBD
4938	Space Developmental Planning	0	4,980	0	0	0	0	0	0	TBD
5021	Space Systems Survivability	0	0	4,030	4,256	4,874	5,008	5,142	Continuing	TBD
682J	Spacecraft Vehicles	7,681	8,573	9,153	9,785	10,580	10,790	10,995	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0	Continuing	TBD

Note: In FY 2002, efforts were transferred from PE 0603410F, Space Systems Environmental Interactions Technology, into Project 4400 in this PE, in order to align projects within the Air Force Research Laboratory organization. In FY 2003, selected efforts in Project 4400, were transferred within this PE into Project 5021, in order to focus on improving survivability of space systems in natural environments.

(U) A. Mission Description

This program develops, integrates, and demonstrates space technologies in the areas of spacecraft payloads, spacecraft protection, spacecraft and launch vehicles, and space systems survivability. The integrated space technologies are demonstrated by component or system level tests on the ground or in flight. Note: Congress added $7.0 million in FY 2002 ($6.0 million for Scorpius Low-Cost Launcher and $1.0 million for Next Generation Hybrid Orbital Maneuver Vehicle).

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(U) B. Budget Activity Justification

This program is in Budget Activity 3, Advanced Technology Development, since it develops and demonstrates technologies for existing system upgrades and/or new system developments that have military utility and address warfighter needs.

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

		FY 2001	FY 2002	FY 2003	Total Cost
(U)	Previous President's Budget	63,019	54,528	50,373	
(U)	Appropriated Value	63,602	61,528		
(U)	Adjustments to Appropriated Value				
	a. Congressional/General Reductions		-596		
	b. Small Business Innovative Research	-1,498			
	c. Omnibus or Other Above Threshold Reprogram				
	d. Below Threshold Reprogram	-350			
	e. Rescissions	-583			
(U)	Adjustments to Budget Years Since FY 2002 PBR			-8,058	
(U)	Current Budget Submit/FY 2003 PBR	61,171	60,932	42,315	TBD

(U) Significant Program Changes:

In FY 2003, decrease in funding due to the realignment of funding to higher priority S&T programs and the termination of Warfighter-1 operations in Project 3834.

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

DATE: February 2002

BUDGET ACTIVITY: 03 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 2181

COST ($ in Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
2181	Spacecraft Payloads	15,357	17,061	14,066	15,276	16,398	16,719	17,040	Continuing	TBD

(U) A. Mission Description

This project funds the development, demonstration, and evaluation of radiation-hardened space electronic hardware, and satellite control hardware and software for advanced satellite surveillance operations. Improved space-qualifiable electronics and software for data and signal processing will be more interchangeable, interoperable, and standardized. In the near-term, this project's work concentrates on converting (i.e., radiation-hardening) commercial data and signal processor technologies for use in Air Force space systems. For mid-term applications, the Improved Space Computer Program (ISCP) will merge advanced, radiation-hardened space processor, memory, and interconnect technologies with commercially-derived, open system architectures to develop and demonstrate robust, on-board processing capabilities for 21st century DoD satellites. In the long-term, this project area focuses on developing low-cost, easily modifiable software and hardware architectures for fully autonomous constellations of intelligent satellites capable of performing all mission related functions without operator intervention.

(U) FY 2001 ($ in Thousands)

(U) $8,311 Developed advanced radiation-hardened microelectronic devices, including space data processors and ultra-high density strategically hardened memories, space-qualifiable, high density advanced packaging technology for digital, analog, and mixed-signal electronic devices, and micro-electro-mechanical systems (MEMS) components and applications, such as switches and optical components. These devices and technologies enable next generation high performance, small, lightweight, efficient, and reliable on-board space electronic systems. Fabricated and demonstrated radiation-hardened Power PC. Insert Next Generation Space Processor design and hardware into flight demonstration system. Designed specifications, built, and demonstrated ground-based computer based on Improved Space Architecture concept. Demonstrated MEMS switches for reconfigurable space electronic applications. Continued the development of packaging and MEMS technologies that enhance/enable optical cross-links and demonstrate the 400 Megabit per second data transfer. Developed reconfigurable electronics and initial plug-and-play system approaches for space.

(U) $1,428 Continued to develop intelligent satellite system technologies for satellite control, precision spacecraft navigation, formation flying, and cluster management technologies for spacecraft constellations. These intelligent satellite systems provide improved capabilities to monitor satellites in real-time, reduce the time required for data collection, processing, and dissemination, an decrease anomaly resolution time and ground operations requirements. Demonstrated intelligent satellite software in the distributed-cluster ground testbed for satellite cluster command and control, cluster formation flying, and executive cluster management. Completed and demonstrated enhanced executive cluster controller and began developing formation flying and orbit determination flight test software and satellite control ground station software.

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(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

(U) $1,306 Continued to develop modeling, simulation, and analysis tools and data exploitation methodologies for space-based surveillance systems and distributed satellite architecture payloads. The modeling, simulation, and analysis (MS&A) tools provide data and validate research and development systems engineering level technology trade off decisions for space-based surveillance missions/campaign level assessments and for intelligent satellite systems testbeds. Delivered simulation architecture tools for satellite constellation-level modeling and validate these tools across the broader modeling and simulation space community. Demonstrated existing space surveillance simulations to support New World Vista's Global Awareness Virtual Testbed. Demonstrated MS&A software and tools in the distributed satellite architecture simulation testbed. Completed exploitation of the hyperspectral imaging data received from the Fourier Transform Hyperspectral Imager payload and assemble data images for target identification and image evaluation for commercial and military purposes.

(U) $1,992 Developed advanced space infrared technology and hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of hot targets, as well as 'cold body' targets such as decoys, satellites, and midcourse warheads. Designed low temperature, multi-color, and low background detectors and focal plane arrays and higher temperature focal plane arrays with higher levels of radiation-hardness. Began development of longer wavelength mercury cadmium telluride focal plane arrays, higher operating temperatures for mid-wavelength infrared focal plane arrays, and focal plane arrays with optimal background-limited performance for stressing space backgrounds.

(U) $2,320 Developed satellite antenna technologies that maximize the use of high density interconnects, embedded the electronics directly onto the antenna itself, and used antenna modules to create large, light space antennas. Satellite antenna technologies will be used to improve affordability and capability of antenna modules for space-based payload subsystems for Air Force surveillance and navigation efforts. Completed design of selected embedded-structural transmit-receive electronics antenna modules. Designed antenna modules which address the requirement for minimizing mass and power by embedding lightweight electronics in the structure itself. Continued fabrication of modular phased-array antenna tile. Completed data analysis on receive-only sub-antenna array data.

(U) $15,357 Total

(U) FY 2002 ($ in Thousands)

(U) $10,409 Develop spacecraft microelectronic devices which will include radiation-hardened data processors and ultra-high density strategically hardened memories, space-qualifiable, high density advanced packaging technology, and micro-electro-mechanical systems components and applications. Design advanced general purpose embedded processors capable of performing at 500 million instructions per second. Design digital signal processors capable of performing at 1 billion operations per second. Perform full-scale integration of chalcogenide programmable memory elements into high density, low power chips. Investigate integration of chalcogenide into other component applications. Extend

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		fabrication capability for application specific integrated circuit technology for upwards to eight million gate devices. Develop and demonstrate a micro-electro-mechanical systems switch box that will use discrete components with non-radiation-hardened control circuitry. Investigate the miniaturization of optical cross-links for advanced packaging applications.
(U)	$1,738	Continue to develop intelligent satellite system technologies for satellite control, precision navigation, formation flying, and cluster management technologies for spacecraft constellations. Develop flight-ready microsatellite cluster management software. Complete and demonstrate flight-ready microsatellite flying algorithms and initiate development of command and control and navigational capability to perform high-fidelity spacecraft proximity operations. Develop a virtual cluster control ground station capable of commanding and controlling multiple satellite clusters. Initiate development of automated planning and scheduling software and integration of distributed payload processing algorithms with the flight software. Develop a spacecraft and simulation data archiving and storage system.
(U)	$858	Continue to develop modeling, simulation, and analysis tools and data exploitation methodologies for space-based surveillance systems and distributed satellite architecture payloads. Build models for sparse, distributed aperture radio frequency (RF) system simulation to support technology trades, systems engineering, and design reviews for near-term flight test experiments. Build models of sparse aperture RF distributed signal processing to be validated against flight experiment and for systems analysis.
(U)	$2,527	Develop advanced space infrared technology and hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of hot targets, as well 'cold body' targets such as decoys, satellites, and midcourse warheads. Fabricate and deliver low temperature multi-color and low background detectors and focal plane arrays, and higher temperature arrays with improved radiation-hardness. Continue iterative development of longer wavelength mercury cadmium telluride focal plane arrays, higher operating temperature mid-wavelength infrared focal plane arrays, and focal plane arrays with optimal background-limited performance for stressing space backgrounds.
(U)	$1,529	Develop satellite antenna technologies that maximize the use of high density interconnects, embed the electronics directly onto the antenna itself, and use antenna modules to create large, light space antennas. Satellite antenna technologies will be used to improve the affordability and capability of antenna modules for space-based payload subsystems for surveillance and navigation efforts. Fabricate selected embedded-structural transmit-receive electronics antenna modules. Design antenna modules that address requirements for minimizing mass and power by embedding lightweight electronics in the structure. Complete fabrication of modular phased-array antenna tiles. Integrate tiles into modules for performance characterization.
(U)	$17,061	Total

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands)

(U) $8,475 Develop spacecraft microelectronic devices, including radiation-hardened data processors and ultra-high density strategically hardened memories, space-qualifiable, high density advanced packaging technology, and micro-electro-mechanical systems (MEMS) components and applications. Perform simulations and validate designs of a general purpose embedded processor at 500 million instructions per second and digital signal processors at 1 billion operations per second. Fabricate and characterize high density, low power chips comprised of innovative chalcogenide programmable memory elements. Begin integration of chalcogenide into components such as field programmable logic and analog microelectronics. Develop macrocell libraries for application specific integrated circuit technology for up to eight million gate devices. Develop and demonstrate a MEMS-based switch box multi-chip module and associated heuristics for multi-switch box applications to smart-wiring manifolds.

(U) $1,797 Continue to develop intelligent satellite system technologies for satellite control, precision navigation, formation flying, and cluster management technologies for spacecraft constellations. Complete and deliver microsatellite cluster management software and integrate the distributed architecture test bed in preparation for a flight demonstration of collaborating three microsatellite constellation. Continue development of command and control and navigational capability for high fidelity spacecraft proximity operations. Continue to develop automated planning and scheduling software for multiple satellite clusters and the spacecraft and simulation data archiving and storage system. Begin development of guidance, navigation, and control algorithms for a tethered power generation system.

(U) $929 Continue to develop modeling, simulation, and analysis tools and data exploitation methodologies for space-based surveillance systems and distributed satellite architecture payloads. Complete models for sparse, distributed aperture radio frequency (RF) system simulation to support technology trades, systems engineering, and design reviews for near-term flight test experiments. Complete models of sparse aperture RF distributed signal processing to be validated against flight experiment and for systems analysis. Begin building mission operations center to support the collaborating three microsatellite constellation flight experiment.

(U) $493 Develop advanced space infrared technology and hardened focal plane detector arrays to enable acquisition, tracking, and discrimination of hot targets, as well 'cold body' targets such as decoys, satellites, and midcourse warheads. Demonstrate and characterize low temperature multicolor and low background detectors and focal plane arrays, and higher temperature arrays with improved radiation hardness. Fabricate and deliver longer wavelength mercury cadmium telluride focal plane arrays, higher operating temperature mid-wavelength infrared focal plane arrays, and focal plane arrays with optimal background-limited performance for stressing space backgrounds. Transition multicolor quantum well photodetector designs and other promising infrared technologies to large focal plane arrays.

(U) $2,372 Develop satellite antenna technologies which maximize the use of high density interconnects, embed the electronics directly onto the antenna itself, and use antenna modules to create large, light space antennas. Test and integrate selected embedded-structural transmit-receive

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(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

electronics antenna modules with payloads for three microsatellite constellation space flight experiment. Test, integrate, and evaluate multi-beam, wide-bandwidth transmit-receive electronics antenna modules with payloads for possible airborne, multi-mode flight experiment. Fabricate and test antenna modules which address requirements for minimizing mass and power by embedding lightweight electronics in the structure.

(U) $14,066 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:
(U) PE 0303601F, MILSTAR Satellite Communications System.
(U) PE 0305160F, Defense Meteorological Satellite Program (DMSP).
(U) PE 0602601F, Spacecraft Technology.
(U) PE 0603311F, Ballistic Missile Technology.
(U) PE 0603215C, Limited Defense System
(U) PE 0603218C, Research and Support.
(U) PE 0603226E, Experimental Evaluation of Major Innovative Technologies.
(U) PE 0604609F, Reliability and Maintainability Technology Insertion Program (RAMTIP).
(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.

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DATE: February 2002

BUDGET ACTIVITY: 03 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 3834

COST ($ in Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
3834	Integrated Space Technology Demonstrations	32,831	24,268	12,268	20,931	18,967	25,853	26,344	Continuing	TBD

(U) A. Mission Description

The Integrated Space Technology Demonstration (ISTD) program is a series of advanced technology demonstrations designed to address mission needs by applying emerging technologies from the Air Force Research Laboratory, other Government laboratories, and industry. These technologies are integrated into system-level demonstrations that are used to test, evaluate, and validate the technologies in an operational environment. Note: In FY 2002, Congress added $7.0 million ($6.0 million for Scorpius Low-Cost Launcher and $1.0 million for Next Generation Hybrid Orbital Maneuver Vehicle).

(U) FY 2001 ($ in Thousands)

(U) $4,803 Continued to develop Warfighter-1, the first in the series of Integrated Space Technology Demonstration systems. Warfighter-1 was an inexpensive space-based hyperspectral imagery system intended for technology validation by a user in a tactical environment. Hyperspectral imaging sensors provide improved capabilities for the warfighter in target detection, terrain classification, and related surveillance applications. Launched Warfighter-1, however, the payload did not reach orbit due to failure of the launch vehicle.

(U) $0 Develop and demonstrate precision ballistic missile navigation technologies to improve accuracy during reentry and in plasma and jamming environments. These technologies will mitigate the detrimental effects of reentry plasma and jamming on Global Positioning System (GPS) navigation performance. Conduct reentry plasma physics characterization and demonstration planning, and continue development and demonstration of miniaturized jam-resistant GPS receivers.

(U) $3,242 Developed microsatellite (10-100kg) technologies and integrated microsatellite technology concepts. Began design of second satellite in the XSS microsatellite series. Studied bus requirements and potential designs. Developed guidance and navigation and maneuvering software and hardware technologies and proximity operations sensor package.

(U) $1,860 Developed technologies for the Communications/Navigation Outage Forecasting System (C/NOFS) demonstration. C/NOFS will demonstrate the capability for forecasting outages to GPS navigation and satellite communications links, providing the warfighter with information on communications and navigation outages. This allows the preemptive use of backup systems and alternate links, which aids anomaly resolution, and facilitates mission/operations planning. Developed data processing unit. Verified payload interface and support spacecraft development and pre-planning of sensor suite integration and testing.

(U) $6,287 Developed scalable booster technologies for low-cost launch vehicles. Continued development of the Sprite orbital demonstration vehicle for launching small payloads at significantly reduced cost. Developed and tested 20,000-lb. thrust flight-weight ablative Sprite booster engine.

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(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

Developed and tested all composite liquid oxygen propellant tank for the Sprite vehicle. Began systems analysis for a Sprite 2,000-lb. thrust upper stage engine. Continued development and demonstration of hydroxyl ammonium nitrate/triethanol amine nitrate mixing gas generator tank pressurization technology.

(U) $4,837 Developed and demonstrated a low-cost, liquid propellant, expendable upper stage in a cooperative effort with National Aeronautics and Space Administration (NASA). Designed, fabricated, and tested a flight ready integrated expendable upper stage.

(U) $9,287 Developed and demonstrated technologies for a military-unique, reusable, satellite bus and upper stage for the Military Spaceplane system. Developed advanced reusable rocket engine technologies for the Space Maneuver Vehicle (SMV) X-40 second tail number flight test article. Continued to develop technologies for the SMV, such as retractable solar arrays for longer on-orbit duration and fine attitude control system to enable proximity operations and precision sensor pointing, and applied the technologies to the X-37 demonstrator to improve military utility and leverage the NASA investment.

(U) $2,515 Developed and demonstrated propulsion and power technologies for solar thermal orbit transfer vehicle. These technologies will enable an affordable orbit transfer vehicle for inspection, reposition, and servicing of space assets above low earth orbit. Developed and built modular heat exchanger to enable scaling to operational size. Developed and built flight experiment scale test article of the inflatable concentrator and feedback control sensor and actuators. Developed control system algorithms and simulations and ground test algorithms with feedback control sensor.

(U) $32,831 Total

(U) FY 2002 ($ in Thousands)

(U) $594 Complete the Warfighter-1 technology demonstration effort, which was intended to provide an inexpensive space-based hyperspectral imagery system for user validation in a tactical environment. Complete final reports, detailing and evaluating lessons learned from the Warfighter-1 development and commercial leveraging efforts.

(U) $1,609 Develop autonomous microsatellite (10-100kg) technologies for an integrated, robust, flexible, modular microsatellite technology concept. Develop microsatellite technologies for non-cooperative, autonomous operational concept and mission planning tools.

(U) $10,749 Design, develop, integrate and test an autonomous microsatellite to demonstrate integrated technology concepts for operations around a non-cooperative, resident space object. Perform design reviews and begin component/hardware fabrication for an autonomous operations microsatellite. Develop plans for launch vehicle integration and safety analysis.

(U) $4,383 Develop microsatellite system test scenarios and design microsatellite hardware-in-the-loop, software simulations, and mission

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

planning/training tools.

(U) $5,942 Develop scalable booster technologies and a flight vehicle demonstrator for low-cost launch vehicles. Develop the detailed design and fabricate long-lead components for the SR-XM-2 suborbital flight vehicle. Perform post injector design modification developmental test firings and engine qualification firings for the 20,000 lb. thrust flight-weight ablative booster engine for the SR-XM-2.

(U) $991 Develop technologies for a small, hybrid propulsion module capable of transferring selected Space Shuttle payloads to higher operational orbits after deployment. This orbital maneuvering capability will reduce both launch cost and risk, while enabling payloads to reach optimal orbit. Develop a conceptual design for the propulsion module that meets National Aeronautics and Space Administration safety and performance requirements. Design, fabricate, and ground test critical, high-risk propulsion module components, evaluating both performance and safety aspects.

(U) $24,268 Total

(U) FY 2003 ($ in Thousands)

(U) $1,873 Develop autonomous microsatellite (10-100kg) technologies for an integrated, robust, flexible, modular microsatellite technology concept. Perform mission operations concept trades using hardware- software-in-the-loop simulations and mission planning tools for non-cooperative proximity operations.

(U) $8,908 Design, develop, integrate, and test autonomous microsatellite to demonstrate integrated technology concepts for operations around a non-cooperative resident space object (RSO). Complete component development and begin system level integration, functional, and environmental test activities in preparation for launch and operations. Perform final launch vehicle safety analysis and ground test and evaluation.

(U) $1,487 Use microsatellite hardware-in-the-loop and software simulations to perform comprehensive ground testing of the autonomous micro-satellite around a non-cooperative RSO.

(U) $12,268 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602601F, Spacecraft Technology.

(U) PE 0603605F, Advanced Weapons 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.

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DATE: February 2002

BUDGET ACTIVITY: 03 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 4400

COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
4400 Space Systems Protection	5,302	6,050	2,798	3,075	3,545	3,617	3,685	Continuing	TBD

Note: In FY 2002, efforts were transferred from PE 0603410F, Space Systems Environmental Interactions Technology, into this project in order to align projects within the Air Force Research Laboratory organization. In FY 2003, selected efforts were transferred within this PE from this project into Project 5021 in order to focus on improving survivability of space systems in natural environments.

(U) A. Mission Description

This project develops and demonstrates tools, instruments, and mitigation techniques required to assure operation of U.S. space assets in potentially hostile warfighting environments. The project performs assessments of critical components and subsystems, and evaluates susceptibility and vulnerability to radio frequency and laser threats. This project also develops technologies that mitigate identified vulnerabilities. Technologies are developed and demonstrated to support balanced satellite protection strategies for detecting, avoiding, and operating in a hostile space environment.

(U) FY 2001 ($ in Thousands)

(U) $43 Used multi-threat assessment tool to evaluate space-based electro-optical sensor responses to various candidate laser countermeasures. Provides space platform designees a rapid and robust assessment tool for accurate assessment of various countermeasures. Began development of passive satellite countermeasures and appropriate mitigation techniques.

(U) $567 Continued to develop on-board satellite warning technologies and tools to detect, geolocate, and characterize the receipt of intentional and unintentional ground-based radio frequency (RF) signals. Began design of integrated RF receiver/laser sensor hardware with weight and power savings compared to individual sensor packages.

(U) $338 Developed RF threat warning receiver for a one-year space flight. Completed RF receiver data analysis, evaluated receiver performance to identify design changes to optimize performance, and incorporated changes into receiver design to reduce performance risk for the one-year flight. Conducted assessment of weapons effects on satellite components and systems.

(U) $1,452 Developed and demonstrated technologies for the Miniature Satellite Threat Reporting System (MSTRS). MSTRS technologies enable detection of ground-based RF threats to satellites from a variety of space platforms. Demonstrated threat reporting package on shuttle flight STS-107. Designed, fabricated, and demonstrated miniaturized instantaneous frequency measurement unit, power divider circuits, and high frequency circuit interconnects.

(U) $2,902 Developed spacecraft protection technologies applicable to commercial and military space satellites to assure operation of space assets. Developed the capability to assess hardware/software threat susceptibility and vulnerability and developed technologies to mitigate identified

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(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

vulnerabilities. Developed and exercised modeling and simulation tools to extend the current understanding of susceptibility of different commercial satellite subsystems to multi-threat environments. Developed radio frequency (RF) and laser threat and effects models to evaluate case studies of existing and developing space systems.

(U) $5,302 Total

(U) FY 2002 ($ in Thousands)

(U) $256 Use multi-threat assessment tool to evaluate space-based electro-optical responses to various candidate RF and laser countermeasures. Add interface for analyzing RF and laser interaction effects on satellites. Add response models for satellite subsystems, such as communications, power, and inertial measurement units.

(U) $2,065 Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites. Conduct plasma shield experiments to determine effectiveness of filtering the radio frequencies to allow only selected frequencies to reach the satellite communications antennas. Initiate evaluations and ground-based demonstrations of visible and near-infrared laser protection techniques in preparation for space demonstrations. Initiate assessments of the impact of satellite self-protection and situational awareness technologies on space systems operations.

(U) $1,441 Develop sensors to specify and forecast conditions in the space environment that degrade the operation of space-based systems. Support integration, launch, and on-orbit operations of instrumentation to improve space radiation hazard specification and forecasting. Specifying and forecasting hazardous space conditions will improve space system designs and lifetime, and enhance operational capabilities for the warfighter. Initiate integration of plasma sensor for the Communications/Navigation Outage Forecasting System onto payload. Launch all-sky camera to detect solar disturbances one to three days prior to Earth impact and complete initial on-orbit validation. Complete integration of relativistic detector for mission to map the dynamic radiation belts and quantify hazards to space systems.

(U) $996 Conduct collaborative experiments and develop tools to improve the survivability of advanced spacecraft power, communications, and surveillance systems. Develop preliminary design of second-generation miniaturized charge control system to autonomously protect satellites from harsh charging environments. Initiate conceptual design of an experiment to quantify the effects of space plasma on tethered power generation systems. Develop interface between dynamic space plasma and meteor specification and forecast models and web-based spacecraft charging design tool.

(U) $1,292 Develop technology to warn of spacecraft charging, chemical contamination, and kinetic impact hazards and to mitigate the effect of the space environment on Department of Defense space systems. Space environment hazard warnings minimize loss of space assets due to component

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

and system level failures and, when widely deployed, provide global situational awareness of hazards. Control of spacecraft charging levels and high-energy radiation effects will significantly improve space system reliability and availability and reduce operational costs. Complete validation of compact environment anomaly sensor for geosynchronous and highly elliptic orbits and transition to operational use. Develop detailed design for miniaturized space environment distributed anomaly resolution sensor for on-orbit detection of space particle, chemical, and impact hazards. Complete ground tests of particle enhancement and depletion technologies and begin conceptual design of active wave and electron beam space experiment to demonstrate the feasibility of satellite protection technologies.

(U) $6,050 Total

(U) FY 2003 ($ in Thousands)

(U) $432 Use multi-threat assessment tool to assess space-based electro-optical responses to various candidate radio frequency and laser countermeasures. Begin verification and accreditation of weapons effects satellite assessment tools, complete documentation for users, and continue to develop additional tools for satellite subsystems, such as processor assemblies, optical trains, and satellite buses.

(U) $1,587 Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites. Continue development of the plasma shield to selectively filter the radio frequencies reaching the satellite communications antennas; prepare for conceptual space demonstration. Conduct design and trade studies and analyses to determine the impact of satellite self-protection and situational awareness technologies on space systems operations. Develop technologies to support automatic wartime deployment of protection technologies for satellites whose peacetime mission would be compromised by on-board protection systems. Investigate electronic protection techniques for optical sensors and systems.

(U) $779 Develop and demonstrate visible and near-infrared laser protection technologies. Continue evaluations and ground-based demonstrations of visible and near-infrared laser protection techniques in preparation for space demonstrations.

(U) $2,798 Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Related Activities:

(U) PE 0602102F, Materials.

(U) PE 0602601F, Spacecraft Technology.

(U) PE 0603605F, Advanced Weapons 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 2002

BUDGET ACTIVITY: 03 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 4938

COST ($ in Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
4938	Space Developmental Planning	0	4,980	0	0	0	0	0	0	TBD

(U) A. Mission Description

This project funds the developmental planning for military space technologies. The project focuses on the Pre-Milestone I systems engineering and integration, studies and analysis, concept development, and architecture efforts needed to transition technology into promising space concepts, capabilities, and systems. Of particular importance is the analysis work performed to link military technologies to mission needs through the strategy-to-task methodology of the Air Force modernization process (AFPD 10-14). Another key aspect of this project is the defining, refining, and demonstrating of select space concepts offering significant future military utility to the warfighter, especially those that integrate existing or planned capabilities from across the entire national space community. A key component of this program is the demonstration of future space capabilities for wargames, exercises, experiments, and demonstrations. This project also funds Modeling and Simulation tools and related infrastructure development that are necessary to conduct studies and provide analysis on future space concepts and capabilities.

(U) FY 2001 ($ in Thousands)

(U) $0 No Activity

(U) $0 Total

(U) FY 2002 ($ in Thousands)

(U) $1,015 Conduct concept development on promising space concepts. Products include comprehensive, high-level, integrated and scientifically sound design solutions across the myriad of space disciplines. Functions include space concept design, cost engineering, and measure of performance/ effectiveness inputs to Air Force Space Command's Optimizer of Utility Toolkit model.

(U) $1,186 Conduct in-depth studies and analysis to assess and quantify the military worth of select space concepts. Provides decision-aiding analysis on space capabilities 15 to 25 years into the future.

(U) $1,027 Conduct continuing system-of-systems engineering and integration for promising space concepts. Defines and refines concepts offering significant military utility to the warfighter, focusing on the integration of air and space capabilities. Supports systems security protection measures for current and planned capabilities across the national space community.

(U) $963 Develop capability to demonstrate relationship, impacts, and effects of space assets on the military campaign in Air Force campaign and theater simulation models/tools to include processing and presentation hardware and software, model database upgrades, and networking and leased

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

		communications lines to support virtual and distributed simulation capability.
(U)	$512	Develop and integrate architectural concepts addressing technology transition opportunities against space mission deficiencies and needs.
(U)	$277	Decrease the time to transition innovative space technology to the warfighter by demonstrating promising future space capabilities in exercises, wargames, experiments, and demonstrations.
(U)	$4,980	Total

(U) FY 2003 ($ in Thousands)

(U)	$0	No Activity
(U)	$0	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) Not Applicable.

(U) D. Acquisition Strategy

Not Applicable.

(U) E. Schedule Profile

(U) Not Applicable.

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

DATE: February 2002

BUDGET ACTIVITY: 03 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 5021

COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
5021 Space Systems Survivability	0	0	4,030	4,256	4,874	5,008	5,142	Continuing	TBD

Note: In FY 2003, efforts were transferred within this PE from Project 4400 into this project, in order to focus on improving survivability of space systems in natural environments.

(U) A. Mission Description

This project develops and demonstrates technologies to improve space system survivability and reliability of current and future Department of Defense space systems that must continue operation despite natural space hazards. It develops and demonstrates cost-effective solutions to mitigate hazardous space environmental interactions including electrical charge buildup and electronics failures due to both single radiation events and long-term radiation doses.

(U) FY 2001 ($ in Thousands)
(U) $0 No Activity
(U) $0 Total

(U) FY 2002 ($ in Thousands)
(U) $0 No Activity
(U) $0 Total

(U) FY 2003 ($ in Thousands)
(U) $985 Develop sensors to specify and forecast conditions in the space environment that degrade the operation of space-based systems. Support integration, launch, and on-orbit operations of instrumentation to provide improved space radiation hazard specification and forecasting. Complete validation of solar disturbances forecasting algorithms using space-based all-sky camera. Launch relativistic electron and proton detector and demonstrate ability to perform on-orbit mapping of the dynamic radiation belts to quantify hazards to space systems. Begin conceptual design of advanced all-sky, white light camera for operational space weather forecasting system.
(U) $1,004 Conduct collaborative experiments and develop tools to improve the survivability of advanced spacecraft power, communications, and surveillance systems. Complete design and begin fabrication design of second-generation miniaturized charge control system. Complete conceptual design of an experiment to quantify the effects of space plasma on tethered power generation systems and determine feasibility of a space flight test to demonstrate on-orbit electrical power generation. Complete interface between dynamic space plasma and meteor models and web-based spacecraft design tools.

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BUDGET ACTIVITY: 03 - Advanced Technology Development	PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology
	PROJECT: 5021

(U) A. Mission Description Continued

(U) FY 2003 ($ in Thousands) Continued

(U)	$2,041	Develop technology to warn of spacecraft charging, chemical contamination, and kinetic impact hazards and to mitigate the effect of the space environment on Department of Defense space systems. Develop data assimilation techniques to produce improved dynamic radiation belt models using data from a fleet of compact environment anomaly sensors. Begin fabrication of miniaturized space environment distributed anomaly resolution sensor for on-orbit detection of space particle, chemical, and impact hazards. Develop detailed design of active wave and electron beam space experiment to demonstrate the feasibility of satellite protection technologies.
(U)	$4,030	Total

(U) B. Project Change Summary

Not Applicable.

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

(U) PE 0602601F, 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 2002

BUDGET ACTIVITY: 03 - Advanced Technology Development

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT: 682J

COST ($ in Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
682J Spacecraft Vehicles	7,681	8,573	9,153	9,785	10,580	10,790	10,995	Continuing	TBD

(U) A. Mission Description

This project develops and demonstrates compact, low-cost, spacecraft and launch vehicle power generation, storage, distribution, and thermal management technologies, including cryogenic cooling technologies. Power generation activities focus on lightweight, low-cost, low-volume, and survivable solar cell arrays. Energy storage work focuses on lightweight nickel hydrogen and sodium sulfur spacecraft batteries and flywheel energy storage systems for extended (five to ten year) satellite missions. The project's power distribution efforts focus on producing lightweight, high-efficiency, standardized power busses for use on future Air Force space programs.

(U) FY 2001 ($ in Thousands)

(U) $1,863 Developed and evaluated the performance of space conventional power generation technologies such as multi-junction solar cells, advanced thin film solar cells, lightweight flexible arrays of thin film solar cells, and radiation resistant solar cell modules. Continued development of lightweight flexible arrays of thin film solar cells and radiation resistant solar cell modules. Continued evaluation of 35% efficient multi-junction solar cells and 12% efficient thin film solar cells.

(U) $788 Developed innovative space conventional energy storage technologies such as the lightweight flywheel integrated power and attitude control system which employs non-electrochemical energy storage. Continued flywheel ground demonstration and development of flywheel safety technologies. Began microflywheel development.

(U) $1,055 Developed technologies for long-life, efficient, low vibration, lightweight mechanical cryocoolers for space applications at temperatures ranging from 10K to 150K. Completed 10K model cryocooler.

(U) $1,254 Developed composites for launch vehicles and spacecraft structures, including grid stiffened launch vehicle shrouds and lightweight thermal protection structures for reusable launch vehicles, and for space applications, such as lightweight space antennas. Developed spacecraft to demonstrate multifunctional structures technologies. Composite and multi-functional structures will be lighter and more affordable, with improved functionality, reducing fabrication and launch costs and enabling applications such as large aperture sensing systems. Ground tested and characterized operational grid stiffened structure. Continued development of inflatable structures. Begin ground test of multi-functional structures. Developed full-scale secondary payload adapter structure for an expendable launch vehicle.

(U) $2,721 Developed and demonstrated revolutionary spacecraft structural control and mechanisms technologies for on-orbit applications such as advanced high power solar array subsystems, sensitive payload isolation systems, and miniature payload isolation systems for sensors and

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	PROJECT: 682J

(U) A. Mission Description Continued

(U) FY 2001 ($ in Thousands) Continued

communications systems. Developed launch vibration isolation and primary and secondary payload isolation systems to meet specific launch vehicle requirements. These technologies will enhance platform stability, enable applications such as precision pointing and sensing, protect payloads on orbit and increase payload lifetime, reduce launch environment problems, decrease spacecraft weight, and reduce failures. Tested miniature vibration suppression systems. Developed smart passive payload isolation systems. Ground demonstrated active acoustic attenuation system. Flight demonstrated simplified low shock separation device.

(U) $7,681 Total

(U) FY 2002 ($ in Thousands)

(U) $1,990 Develop and evaluate performance of space conventional power generation technologies such as multi-junction solar cells, advanced thin film solar cells, lightweight flexible solar cell arrays, and radiation resistant solar cell modules. Ground demonstrate deployment and operation of large, free-flying, lightweight, flexible, radiation resistant, array of thin film solar cells. Integrate 35% efficient multi-junction solar cells and 12% efficient thin film solar cells into large modules. Begin integration into full arrays.

(U) $822 Develop space conventional energy storage technologies such as the lightweight flywheel integrated power and attitude control system. Ground demonstrate integrated attitude control and energy storage system. Evaluate feasibility of microflywheel technology based on conceptual design; fabricate and test microflywheel components.

(U) $1,356 Develop technologies for long-life, efficient, low vibration, lightweight mechanical cryocoolers for space applications. Characterize performance of 10K model cryocooler. Develop and deliver high efficiency multi-stage cryocooler with radiation-hardened control electronics. Begin development of high capacity multi-stage 10K cryocooler system for advanced space surveillance and tracking sensor.

(U) $1,303 Develop composites for launch vehicle and spacecraft structures and space applications, such as launch vehicle shrouds, thermal protection structures, and space antennas. Develop spacecraft to demonstrate multi-functional structures technologies. Flight demonstrate grid stiffened shrouds and thermal protection structures. Complete development of inflatable support structures. Continue ground test of multi-functional structures. Initiate integration of power and thermal technologies into multi-functional structures. Ground test full-scale secondary payload adapter structure for an expendable launch vehicle.

(U) $3,102 Develop technologies for spacecraft structural controls and mechanisms for on-orbit applications such as advanced high power solar array subsystems, sensitive payload isolation systems, and miniature payload isolation systems. Develop launch vibration isolation and primary and secondary payload isolation systems to meet specific launch vehicle requirements. Ground demonstrate smart passive payload isolation systems. Design operational active acoustic attenuation system. Develop and ground demonstrate passive acoustic attenuation system.

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(U) A. Mission Description Continued

(U) FY 2002 ($ in Thousands) Continued

Integrate low shock separation devices and whole spacecraft vibration isolation systems. Develop autonomous satellite docking and deployment mechanisms. Develop modular vibration-isolating spacecraft transport container.

(U) $8,573 Total

(U) FY 2003 ($ in Thousands)

(U) $1,833 Develop and evaluate performance of space conventional power generation technologies such as multi-junction solar cells, advanced thin film solar cells, lightweight flexible solar cell arrays, and radiation resistant solar cell modules. Flight demonstrate deployment and operation of large, free-flying, lightweight, flexible, radiation resistant, array of thin film solar cells. Continue integration of 35% efficient multi-junction solar cells and 12% efficient thin film solar cells into full arrays.

(U) $925 Develop innovative space conventional energy storage technologies such as the lightweight flywheel integrated power and attitude control system. Flight demonstrate integrated attitude control and energy storage system. Develop operational microflywheel demonstration system.

(U) $1,386 Develop technologies for long-life, efficient, low vibration, lightweight mechanical cryocoolers for space applications. Continue development of high capacity multi-stage cryocooler technologies to meet the needs of high resolution, space-based infrared surveillance and tracking sensors with larger focal planes and optics.

(U) $1,324 Develop composites for launch vehicle and spacecraft structures and space applications, such as launch vehicle shrouds, thermal protection structures, and space antennas. Develop spacecraft to demonstrate multifunctional structures technologies. Complete evaluation of operational grid stiffened structures. Fabricate multifunctional spacecraft bus for small satellites. Flight demonstrate full-scale Evolved Expendable Launch Vehicle secondary payload adapter structure.

(U) $3,685 Develop technologies for spacecraft structural controls and mechanisms for on-orbit applications such as advanced high power solar array subsystems, sensitive payload isolation systems, and miniature payload isolation systems. Develop launch vibration isolation and primary and secondary payload isolation systems to meet specific launch vehicle requirements. Flight demonstrate smart passive payload isolation systems. Ground demonstrate operational active acoustic attenuation system. Flight demonstrate passive acoustic attenuation system. Integrate low shock separation devices into multiple payload adapter. Ground demonstrate smart docking and deployment mechanisms. Continue development of modular vibration-isolating spacecraft transport container.

(U) $9,153 Total

(U) B. Project Change Summary

Not Applicable.

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PROJECT: 682J	

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

(U) Related Activities:

(U) PE 0602203F, Aerospace Propulsion.

(U) PE 0602601F, Spacecraft Technology.

(U) PE 0603218C, Research and Support.

(U) PE 0603226E, Experimental Evaluation of Major Innovative Technologies.

(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.