PE NUMBER: 0603401F
PE TITLE: Advanced Spacecraft Technology

Exhibit R-2, RDT&E Budget Item Justification

DATE: February 2004

BUDGET ACTIVITY: 03 Advanced Technology Development (ATD)

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

	Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
	Total Program Element (PE) Cost	52.424	96.912	60.124	65.892	72.085	88.248	90.947	Continuing	TBD
2181	Spacecraft Payloads	14.633	22.477	18.013	18.326	19.780	36.219	36.223	Continuing	TBD
3834	Integrated Space Technology Demonstrations	13.243	28.693	18.584	25.057	27.460	26.531	26.716	Continuing	TBD
4400	Space Systems Protection	2.688	9.432	3.473	3.505	3.570	3.630	3.688	Continuing	TBD
4938	Space Developmental Planning	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	TBD
5021	Space Systems Survivability	3.878	4.136	4.775	4.854	4.982	5.066	5.147	Continuing	TBD
5083	Ballistic Missiles Technology	0.000	6.802	6.859	5.815	4.069	4.137	4.204	Continuing	TBD
682J	Spacecraft Vehicles	17.982	25.372	8.420	8.335	12.224	12.665	14.969	Continuing	TBD

Note: 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 and Budget Item Justification

This program develops, integrates, and demonstrates space technologies in the areas of spacecraft payloads, spacecraft protection, spacecraft and launch vehicles, ballistic missiles, space systems survivability, and development of advanced laser communications technologies to support next generation satellite communication systems. The integrated space technologies are demonstrated by component or system level tests on the ground or in flight. Note: In FY 2004, Congress added $1.2 million for Capacitively Coupled Interconnect, $1.5 million for Magnetoresistive Random Access Memory (MRAM) Innovative Communications Materials, $1.7 million for Integrated Spacecraft Engineering Tool, $4.7 million for Radially Segmented Launch Vehicle Risk Reduction, $2.1 million for AESIR Reusable Liquid Oxygen/Liquefied Natural Gas (LOX/LNG) Launch Vehicle Technology, $3.5 million for Hardening Technologies for Spacecraft Protection (HTSP), $4.7 million for Thin Amorphous Solar Arrays, $2.8 million for Robust Aerospace Composite Materials/Structures, and $3.5 million for Boron Energy Cell Development.

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

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BUDGET ACTIVITY 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology

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

		FY 2003	FY 2004	FY 2005
(U)	Previous President's Budget	54.884	72.114	60.282
(U)	Current PBR/President's Budget	52.424	96.912	60.124
(U)	Total Adjustments	-2.460	24.798	
(U)	Congressional Program Reductions		-0.072	
	Congressional Rescissions		-0.830	
	Congressional Increases		25.700	
	Reprogrammings	-1.223		
	SBIR/STTR Transfer	-1.237		

(U) Significant Program Changes:

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

Exhibit R-2a, RDT&E Project Justification			DATE: February 2004
BUDGET ACTIVITY: 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology	PROJECT NUMBER AND TITLE: 2181 Spacecraft Payloads	

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
2181 Spacecraft Payloads	14.633	22.477	18.013	18.326	19.780	36.219	36.223	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

This project funds the development, demonstration, and evaluation of radiation-hardened space electronic hardware, satellite control hardware and software for advanced satellite surveillance operations, and development of advanced laser communications technologies to support next generation satellite communications systems. 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 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 Department of Defense 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) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: 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.	8.117	8.373	8.554

(U) In FY 2003: Performed simulations and validated designs of a general purpose embedded processor at 500 million instructions per second and digital signal processors at 1 billion operations per second. Fabricated and characterized high density, low power chips comprised of innovative chalcogenide programmable memory elements. Integrated chalcogenide into components such as field programmable logic and analog microelectronics. Developed macrocell libraries for application specific integrated circuit technology for up to eight million gate devices. Developed and demonstrated a micro-electro-mechanical based switch box multi-chip module and associated heuristics for multi-switch box applications to smart-wiring manifolds.

(U) In FY 2004: Demonstrate functional elements for general-purpose processor at 500 million instructions per second and digital signal processors at 1 billion operations per second. Develop architectures and design electronics circuits in support of adaptable, self-repairing processors and memories. Demonstrate functional elements of chalcogenide-based field programmable logic and analog microelectronics. Develop hardened-by-design primitive cell libraries enabling the use of state-of-the-art commercial manufacturing plants for high performance, low-cost electronics. Build MEMS and chalcogenide-based switches supporting multi-switch box applications to smart-wiring manifolds.

(U) In FY 2005: Fabricate a general-purpose processor at 500 million instructions per second and digital signal

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
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processors at one billion operations per second. Demonstrate electronics circuits in support of adaptable, self-repairing processors and memories enabling spacecraft capable of autonomously adapting to new missions. Build functional elements of chalcogenide-based field programmable logic and analog microelectronics. Develop hardened by design macrocell libraries enabling the use of state-of-the-art commercial manufacturing plants for high performance, low-cost electronics. Demonstrate elements for hieratical smart-wiring manifolds capable of reconfiguring entire space asset subsystems. Implement the hardened-by-design mixed signal library and the design for analog-to-digital converter demonstration; fabricate devices in the Silicon Germanium process.

(U)

(U) MAJOR THRUST: Develop intelligent satellite system technologies for responsive spacecraft operations and for satellite control, precision navigation, formation flying, and proximity operations technologies for spacecraft constellations.	1.721	2.803	1.808

(U) In FY 2003: Completed initial development of microsatellite cluster management software. Developed command, control, and navigational capability for high fidelity spacecraft proximity operations. Developed automated planning and scheduling software for multiple satellites and the spacecraft and simulation data archiving and storage system. Developed initial guidance, navigation, and control algorithms for proximity operations and large deployable systems. Developed initial autonomous software technologies for responsive space systems.

(U) In FY 2004: Expand the development of command, control, and navigational capability for high fidelity spacecraft proximity operations with application to counterspace operations. Complete development of automated planning and scheduling software for multiple satellites and the spacecraft and simulation data archiving and storage system. Expand development of guidance, navigation, and control algorithms for proximity operations and large deployable systems. Develop initial command and telemetry simulation for mission operations center testing. Further develop autonomous software technologies for responsive space systems.

(U) In FY 2005: Advance development of command, control, and navigational capability for high fidelity spacecraft proximity operations with application to space capability protection. Complete development of guidance, navigation, and control algorithms for proximity operations and large deployable systems. Further command and telemetry simulation development for mission ops center testing. Integrate hardware-in-the-loop engineering development unit into testbed, interface with spacecraft command and telemetry simulations, and begin mission ops center testing.

(U)

(U) MAJOR THRUST: Develop modeling, simulation, and analysis tools and data exploitation methodologies for space-based surveillance systems, space capability protection technologies, access/mobility technologies, and flight experiments.	0.890	0.965	1.298

(U) In FY 2003: Developed models for sparse, distributed aperture radio frequency (RF) system simulation to support technology trades and systems engineering. Expanded models of sparse aperture RF distributed signal processing for systems analysis. Explored models of space-based surveillance systems for technology investment decision support

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **2181 Spacecraft Payloads**

with emphasis on military utility analysis.

(U) In FY 2004: Refine models for sparse, distributed aperture radio frequency (RF) system simulation to support systems engineering. Further develop models of sparse aperture RF distributed signal processing. Refine simulation models of space-based surveillance systems for military utility analysis. Develop initial modeling, simulation, and analysis tools for technical assessment of space capability protection and access/mobility technologies. Develop physics-to-engineering-to-engagement level models for systems engineering, tech trades, mission planning and operations, and utility analysis applicable to potential flight experiments.

(U) In FY 2005: Complete development of models for sparse, distributed aperture RF system simulation. Complete development of sparse aperture RF distributed signal processing models. Expand development of simulations of space-based surveillance systems for military utility analysis. Refine development of modeling, simulation, and analysis tools for technical assessment of space capability protection and access/mobility technologies. Continue to develop physics-to-engineering-to-engagement level models for systems engineering, tech trades, mission planning and operations, and utility analysis applicable to potential flight experiments.

(U)

(U) MAJOR THRUST: Develop 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.	0.473	3.257	2.317

(U) In FY 2003: Demonstrated and characterized low temperature multi-color and low background detectors and focal plane arrays, and higher temperature arrays with improved radiation hardness. Fabricated and delivered 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. Transitioned multi-color quantum well photodetector designs and other promising infrared technologies to large focal plane arrays.

(U) In FY 2004: Characterize higher operating temperature, mid-wave infrared focal plane arrays (FPA). Complete fabrication and characterize higher operating temperature, mid-wave infrared FPAs. Complete fabrication and characterize first-ever dual band (mid-wave, long-wave) FPAs having an extended long-wave infrared response. Investigate radiation hardened-by-design development for long wavelength infrared FPAs for space-based passive surveillance applications. Explore detector interfacing concepts for larger-format, higher capability space hyperspectral imaging systems.

(U) In FY 2005: Complete pathfinder, dual-band ("mid-wave, long-wave") FPA performance characterization and transition plans, and insert technology into a potential hyperspectral demonstration. Characterize and assess performance of long wavelength infrared FPAs developed with "radiation hardened-by-design." Investigate detector array and cryogenic detector multiplexer interfacing concepts that lead to improved, larger-format, space hyperspectral imaging capabilities. Extend performance of dualband vapor phase growth FPAs from moderate

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **2181 Spacecraft Payloads**

	background levels to more stressing lower background levels endemic to space-based passive surveillance.			
(U)				
(U)	MAJOR THRUST: Develop and demonstrate satellite antenna technologies that exploit advanced electronic integration, high-density interconnects/packaging and advanced phased array component technologies to create large, lightweight space antennas.	2.271	1.430	1.903
(U)	In FY 2003: Tested and integrated selected embedded-structural transmit-receive electronics antenna modules for future multi-microsatellite constellation space flight experiment. Tested, integrated, and evaluated multi-beam, wide-bandwidth transmit-receive electronics antenna modules with payloads for possible airborne, multi-mode flight experiment. Fabricated and tested antenna modules that address requirements for minimizing mass and power by embedding lightweight electronics in the structure.			
(U)	In FY 2004: Deliver flight-ready multi-beam, wide-bandwidth antenna modules for airborne multi-mode flight experiment. Redesign baseline antenna module tiles using advanced substrate material to reduce antenna module weight by 25%. Develop and demonstrate ten milliwatt advanced low power, octave-wide bandwidth, low noise amplifier. Apply Application Specific Integrated Circuit technology to achieve a higher level of integration for the transmit-receive cells, reducing discrete components by 25%. Redesign antenna tile architecture to incorporate next generation miniaturized phased array components to support eight simultaneous beams. Design multi-decade-bandwidth antenna architecture.			
(U)	In FY 2005: Achieve an additional 25% reduction in discrete component requirements for the antenna modules by developing wide-bandwidth radio frequency manifold techniques for implementation in baseline antenna module tiles architecture. Complete redesign of tile architecture to incorporate new miniaturized phased array components to support eight simultaneous beams. Demonstration of multi-decade-bandwidth antenna architecture. Investigate design and development of sparse membrane array architectures for next generation agile beam control and smart antenna that extends the transmit/receive technology to autonomous beam control.			
(U)				
(U)	MAJOR THRUST: Develop technologies for multi-access laser communications space terminals with reduced weight, power, and cost for transformational communications.	0.000	0.990	1.946
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Investigate component integration issues and identify technical challenges for potential space experiments of multi-access laser communications systems. Develop initial ground breadboard testbed. Complete space-based laser communications architecture studies.			
(U)	In FY 2005: Explore component integration issues of multi-access laser communications systems. Complete ground breadboard testbed. Test breadboard terminal designs in approved compatibility testbed. Develop initial multi-access laser communications terminal brassboard development.			
(U)				

Exhibit R-2a, RDT&E Project Justification			DATE February 2004
BUDGET ACTIVITY 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology	PROJECT NUMBER AND TITLE 2181 Spacecraft Payloads	

(U) MAJOR THRUST: Develop satellite payload subsystem technologies to exhibit revolutionary capabilities in operability, responsiveness, and cost-effectiveness.	0.000	1.982	0.000
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Develop enabling responsive spacecraft technologies, which include on-the-fly programmable, configurable, logic, and modular, reusable, self-initiating software, as well as technologies that enable rapid satellite integration and minimum time on-orbit satellite checkout.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) MAJOR THRUST: Develop spectral sensing and data exploitation capabilities for military imaging and remote sensing applications. Note: Reflects increased emphasis on spectral sensing technology.	0.000	0.000	0.187
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Demonstrate spectral sensing and data exploitation capabilities for military imaging and remote sensing applications. Analyze technology and modeling results to advance the understanding of electro-optical/infrared polarimetric phenomology and initiate investigations into new instrumentation for space applications. Apply polarimetric signature modeling capability to assess space-based surveillance applications.			
(U)			
(U) CONGRESSIONAL ADD: Capacitively Coupled Interconnect.	1.161	1.190	0.000
(U) In FY 2003: Developed integrated circuit interconnection technology based on non-conductive approaches that provides denser, more powerful computation capabilities, increased bandwidth within and between electronic systems, and improved flexibility and increased reliability. Investigated theoretical basis of capacitively coupled interconnects and assessed their performance against traditional approaches. Formulated and conducted feasibility proof of principle based on findings.			
(U) In FY 2004: Using previously established and proven principles, provide a system level demonstration of a non-conductive interconnection technology, in a form suitable for transfer to industry. Build an electronic system that demonstrates all the advantages of non-conductive interconnection technology in a realistic environment for one form of packaging.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) CONGRESSIONAL ADD: Magnetoresistive Random Access Memory (MRAM) Innovative Communications Materials.	0.000	1.487	0.000
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Develop and characterize a magnetic tunneling junction magnetic memory element 1 by 0.25 micron in size, along with supporting circuitry and architecture models, leading to distributed, radiation-hard, non-volatile			

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BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **2181 Spacecraft Payloads**

memory for embedded and reconfigurable spacecraft computing systems.

(U) In FY 2005: Not Applicable.

(U) Total Cost 14.633 22.477 18.013

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 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.									

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology	PROJECT NUMBER AND TITLE 2181 Spacecraft Payloads

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

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BUDGET ACTIVITY: 03 Advanced Technology Development (ATD)

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT NUMBER AND TITLE: 3834 Integrated Space Technology Demonstrations

Cost ($ in Millions)		FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
3834	Integrated Space Technology Demonstrations	13.243	28.693	18.584	25.057	27.460	26.531	26.716	Continuing	TBD
	Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

This project 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 relevant environment.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop autonomous microsatellite (10-100kg) technologies for an integrated, robust, flexible, modular microsatellite technology concept.	10.342	20.265	18.584

(U) In FY 2003: Performed mission operations concept trades using hardware-/software-in-the-loop simulations and mission planning tools for non-cooperative proximity operations. Completed component development and began system level integration, functional, and environmental test activities in preparation for launch and operations. Performed final launch vehicle safety analysis and ground test and evaluation. Used microsatellite hardware-in-the-loop and software simulations to perform comprehensive ground testing of the autonomous microsatellite around a non-cooperative resident space object.

(U) In FY 2004: Develop and test a laser range finder subsystem. Develop and test the ground control system for real-time planning and flight operations of proximity operations microsatellite. Test autonomous operations software against simulated faults and anomalies. Complete system level integration of microsatellite and complete functional and environmental tests. Integrate microsatellite with launch system and perform functional and environmental tests. Begin integration with launch vehicle. Integrate ground control system and satellite software simulations. Perform simulated proximity operations missions for mission operations training and for determination of the simulated spacecraft performance and interaction with ground controllers.

(U) In FY 2005: Complete development of autonomous proximity operations microsatellites ground control interface system. Perform real time simulated mission experiments beyond spacecraft envelop. Complete satellite/launch vehicle integration and launch. Perform mission operations around one or more non-cooperative resident space objects. Evaluate options for potential follow-on space situational awareness technology demonstration, using operational concept trades. Perform preliminary design concept trades and initial satellite design(s.) Downselect to best payload option. Initiate satellite bus design. Complete preliminary bus and payload design.

(U)

Exhibit R-2a, RDT&E Project Justification			DATE February 2004
BUDGET ACTIVITY 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology	PROJECT NUMBER AND TITLE 3834 Integrated Space Technology Demonstrations	

(U) CONGRESSIONAL ADD: Next Generation Hybrid Orbital Maneuver Vehicle.	0.967	0.000	0.000
(U) In FY 2003: Explored technologies for a small, hybrid propulsion module capable of transferring selected Space Shuttle payloads to higher operational orbits after deployment. Integrated and ground test fired a propulsion module. Test information was used to assess whether the hybrid technology meets the relevant orbital transfer and Space Shuttle safety requirements.			
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) CONGRESSIONAL ADD: Streaker Small Launch Vehicle.	0.967	0.000	0.000
(U) In FY 2003: Developed technologies for small launch vehicles for rapid and affordable deployment of small satellite and Common Aero Vehicle payloads. Conducted trade studies to define a responsive, simple, cost-effective small launch vehicle. Defined preliminary system design requirements and developed a mission model, a system concept, and mission and life cycle cost estimates for a small launch vehicle to place military payloads (200 - 2000 lb.) into Low Earth Orbit.			
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) CONGRESSIONAL ADD: Integrated Spacecraft Engineering Tool (ISET).	0.967	1.686	0.000
(U) In FY 2003: Developed an integrated engineering, modeling, simulation, and design tool to support rapid modeling and collaborative Research, Development, Test, and Evaluation of advanced spacecraft and launch vehicles. This tool enables quick turnaround, advanced space mission analyses that incorporate future military space requirements to determine the impact on system performance and capabilities. Integrated government and commercial design, analysis, and optimization software into a combined systems analysis and design tool set that advances the capability to predict performance benefits and impacts for new technologies on space and launch vehicle systems.			
(U) In FY 2004: Expand the capabilities of an existing integrated engineering, modeling, simulation, and design tool that supports rapid modeling and collaborative Research, Development, Test, and Evaluation of advanced spacecraft and launch vehicles. Enhanced capabilities include modeling of more complex launch vehicle concepts, and vehicle atmospheric reentry performance for studies of future tactical conventional weapons delivery.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) CONGRESSIONAL ADD: Radially Segmented Launch Vehicle (RSLV) Risk Reduction.	0.000	4.660	0.000
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Validate the cost and performance of a rocket engine module used in the RSLV main propulsion system. Validate cost, mass properties, and structural performance of the RSLV segmented tanks through hardware			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **3834 Integrated Space Technology Demonstrations**

fabrication and destructive testing. Demonstrate integrated operation of a segment pair through ground hot fire testing.

(U) In FY 2005: Not Applicable.

(U)

(U) CONGRESSIONAL ADD: AESIR Reusable Liquid Oxygen/Liquefied Natural Gas (LOX/LNG) Launch Vehicle Technology.	0.000	2.082	0.000

(U) In FY 2003: Not Applicable.

(U) In FY 2004: Fabricate and test 30,000 lb. thrust (30K) LOX/LNG engine to establish the feasibility of the basic propulsion concepts. This effort could lead to a relatively high performance, reusable 30K, pump-fed, regeneratively cooled chamber propulsion system and a two-stage-to-orbit vehicle system concept; effort could also lead to a reusable, configurable-plume propulsion system and target vehicle design. The target vehicle will be a relatively simple pressure-fed design to support plume detection and discrimination test objectives.

(U) In FY 2005: Not Applicable.

(U) Total Cost	13.243	28.693	18.584

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost

(U) Related Activities:

(U) PE 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.

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DATE: February 2004

BUDGET ACTIVITY: 03 Advanced Technology Development (ATD)

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT NUMBER AND TITLE: 4400 Space Systems Protection

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
4400 Space Systems Protection	2.688	9.432	3.473	3.505	3.570	3.630	3.688	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: 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 and Budget Item Justification

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) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Use multi-threat assessment tools to assess space-based electro-optical, communication, and other responses to various candidate radio frequency and laser countermeasures and directed energy threats.	0.415	1.861	1.010
(U) In FY 2003: Verified and accredited initial weapons effects satellite assessment tools, completed documentation for users, and developed additional tools for satellite subsystems, such as processor assemblies, optical trains, and satellite buses.			
(U) In FY 2004: Use existing satellite subsystem response data to continue verification of single satellite models of weapons effects for processor assemblies, optical trains, and satellite buses. Integrate single satellite models into satellite constellation analysis tool. Assess electro-optical designs of planned space systems for radio frequency and laser susceptibility and potential mitigation techniques. Assess directed energy threat susceptibility and potential for mitigation techniques for key satellite subsystems, such as communications.			
(U) In FY 2005: Investigate models for radio frequency and laser response in communications and power subsystems and integration into single satellite communications and power subsystem models into satellite constellation analysis tool. Apply constellation analysis tool to wargaming exercises and assess efficacy.			
(U)			
(U) MAJOR THRUST: Develop passive satellite countermeasures and mitigation techniques for current and future threats to satellites.	1.524	2.732	2.022
(U) In FY 2003: Designed plasma shield to selectively filter the radio frequencies reaching the satellite communications antennas; prepared for conceptual space demonstration. Conducted design and trade studies and analyses to determine the impact of satellite self-protection and situational awareness technologies on space systems operations. Explored technologies to support automatic wartime deployment of protection technologies for satellites whose			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **4400 Space Systems Protection**

	peacetime mission would be compromised by on-board protection systems. Explored electronic protection techniques for optical sensors and systems.			
(U)	In FY 2004: Complete plasma shield design and define potential system applications. Refine selected design trade studies and analyses to determine the impact of satellite self-protection and situational awareness technologies on space systems operations. Investigate mitigation technologies such as deployable shields and triggered automatic gain control for radio frequency threats.			
(U)	In FY 2005: Investigate and identify candidate threat mitigation technologies for principle satellite subsystems, such as shielding and terminal protection techniques for multi-chip modules, reconfigurable processors/architectures, and anti-jam modems for uplink subsystems.			
(U)				
(U)	MAJOR THRUST: Develop visible and near-infrared laser protection technologies.	0.749	1.369	0.441
(U)	In FY 2003: Completed initial evaluations and ground-based demonstrations of visible and near-infrared laser protection techniques in preparation for space demonstrations.			
(U)	In FY 2004: Develop adaptive signal processing techniques to mitigate laser interference effects on readout electronics and focal plane array sensor subsystem components. Design and fabricate an optical sensor subsystem incorporating adaptive signal processing techniques. Develop optical sensor subsystem threat mitigation techniques using solutions such as acousto-optical switches to deflect incoming laser energy from the focal plane array.			
(U)	In FY 2005: Demonstrate visible and near-infrared laser protection technologies. Conduct ground test of optical sensor subsystem incorporating selective mitigation approaches. Develop selected protection techniques and evaluate effectiveness as a laser mitigation technique of optical sensor subsystems.			
(U)				
(U)	CONGRESSIONAL ADD: Hardening Technologies for Satellite Protection (HTSP).	0.000	3.470	0.000
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Examine, evaluate, and summarize potential protection techniques that are acceptable to systems designers, with a goal of minimal impacts of additional weight and power, integration issues, and performance loss. Establish relationships with commercial system designers to explore acceptable approaches for applications to commercial systems. Develop and test prospective protection techniques, filters, rugates, and/or limiters applicable for enhanced survivability. Expand ability to accurately predict the nuclear environment associated with a High Altitude Nuclear Event, enhancing the ability of designers to accurately determine their system vulnerability. Complete Version 1 of the Satellite Survivability Module code to include ability to analyze both radio frequency and laser effects within the Satellite Toolkit framework.			
(U)	In FY 2005: Not Applicable.			
(U)	Total Cost	2.688	9.432	3.473

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology	PROJECT NUMBER AND TITLE 4400 Space Systems Protection

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

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2004

BUDGET ACTIVITY: 03 Advanced Technology Development (ATD)

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT NUMBER AND TITLE: 5021 Space Systems Survivability

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5021 Space Systems Survivability	3.878	4.136	4.775	4.854	4.982	5.066	5.147	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

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

(U) A. Mission Description and Budget Item Justification

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) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop sensors to specify and forecast conditions in the space environment that degrade the operation of satellite, communication, navigation, and surveillance systems. Support integration, launch, validation, and operation of instrumentation to provide improved space radiation and ionospheric hazard specification and forecasting.	0.948	1.034	1.432

(U) In FY 2003: Launched, completed initial on-orbit checkout, and commenced validation of solar disturbances forecasting algorithms using space-based all-sky camera. Performed joint agency collaboration to fly relativistic electron and proton detector and demonstrated ability to perform on-orbit mapping of the dynamic radiation belts to quantify hazards to space systems. Developed initial conceptual design of advanced all-sky, white light camera for operational space weather forecasting system.

(U) In FY 2004: Validate solar disturbance forecast algorithms derived from all-sky heliospheric imager. Develop instrument and data plan for joint-agency mission to map the high-intensity region of the radiation belt that limits choices for spacecraft orbits. Expand space weather forecasting system conceptual design to include interplanetary in situ plasma and magnetic field sensors in addition to miniaturized white-light camera. Develop initial micro- and nano-technology based concepts to miniaturize energetic particle, neutral density, and low energy plasma sensors needed to characterize space weather hazards.

(U) In FY 2005: Complete all-sky image based solar disturbance forecast algorithms and transition to military/civilian operational forecasters. Integrate relativistic particle sensor onto joint-agency radiation belt mapping satellite. Investigate development of miniaturized plasma, magnetic field, and all-sky white light cameras for inclusion on interplanetary microsatellites. Determine optimal micro- and nano-technology path to achieve maximum deployable, highest capability energetic particle, neutral density, and low-energy plasma sensors for space weather characterization.

(U)

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology	PROJECT NUMBER AND TITLE 5021 Space Systems Survivability

(U)	MAJOR THRUST: Conduct collaborative space and laboratory experiments and develop hardware and software tools to improve the survivability of spacecraft power, communications, navigation, and surveillance systems.	0.966	1.449	1.911
(U)	In FY 2003: Completed design and began fabrication of second-generation miniaturized charge control system. Completed conceptual design of an experiment to quantify the effects of space plasma on tethered power generation systems and determined feasibility of a space flight test to demonstrate on-orbit electrical power generation. Completed interface between dynamic space plasma and meteor models and web-based spacecraft design tools.			
(U)	In FY 2004: Complete model testing of miniaturized charge control system and begin construction of space experiment for the hazardous geosynchronous environment. Develop a space experiment to validate on-orbit electrical power generation and particle scattering capabilities of space tether. Develop initial suite of comprehensive spacecraft environment effect tools for operational use by integrating full range of environment specification and forecast models with spacecraft hazard, trans-ionospheric link degradation, and satellite drag specification tools. Investigate design of active antenna and passive detection hardware for space experiment to demonstrate techniques of lowering radiation belt intensities to protect satellites.			
(U)	In FY 2005: Integrate geosynchronous charge control system onto space test satellite for on-orbit demonstration of hazard mitigation. Refine space tether experiment hardware and finalize space test plan. Complete integration of ionospheric and satellite drag effects into spacecraft environment effect tool suite. Complete hardware suite selection and begin fabrication of payload for space experiment to actively explore space particle dynamics and demonstrate radiation belt remediation technologies.			
(U)				
(U)	MAJOR THRUST: Develop technology to warn of spacecraft radiation, charging, and kinetic impact hazards and to provide space environment situational awareness and anomaly resolution capability for Department of Defense space systems.	1.964	1.653	1.432
(U)	In FY 2003: Developed data assimilation techniques to produce improved dynamic radiation belt models using data from multiple compact environment anomaly sensors. Fabricated initial components of miniaturized space environment distributed anomaly resolution sensor for on-orbit detection of space particle, chemical, and impact hazards. Developed detailed design of active wave and electron beam space experiment to demonstrate the feasibility of satellite protection technologies.			
(U)	In FY 2004: Complete development of first-generation data assimilation models specifying global radiation levels based on single compact environment anomaly sensor inputs. Complete concept design for space hazard detectors comprising distributed anomaly resolution sensors and begin hardware development. Refine detailed design of active wave and electron beam space experiment to demonstrate the feasibility of satellite protection technologies.			
(U)	In FY 2005: Advance global radiation hazard situational awareness model development by expanding number or sensor inputs to improve accuracy and timeliness. Fabricate flight ready engineering model of distributed space hazard sensors needed for space situational awareness. Complete design of active wave experiment to remediate			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **5021 Space Systems Survivability**

severe radiation environments. Plan for space test flight of active wave and distributed sensor technologies.

(U)	Total Cost	3.878	4.136	4.775

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

		FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U)	PE 0602601F, Spacecraft Technology. This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification

DATE: February 2004

BUDGET ACTIVITY: 03 Advanced Technology Development (ATD)

PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology

PROJECT NUMBER AND TITLE: 5083 Ballistic Missiles Technology

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
5083 Ballistic Missiles Technology	0.000	6.802	6.859	5.815	4.069	4.137	4.204	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

Note: This is a new project, but not a new start. The efforts are part of ongoing work performed in PE 0603311F, Ballistic Missile Technology, and are put in this PE to align efforts within the Air Force Research Laboratory organization.

(U) A. Mission Description and Budget Item Justification

This project develops, integrates, and demonstrates advanced technologies for sustainment and modernization of strategic ballistic missiles. The project focuses on developing robust, low maintenance inertial navigation instruments to sustain current ballistic missile systems, as well as provide new, small, low-powered, high precision instrumentation for next generation missile systems.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: Develop, integrate, and demonstrate advanced navigation instrumentation applied to emerging vehicle designs and other technologies that sustain current strategic missile systems. Provide critical missile technology concepts to support future space force application and strategic systems.	0.000	3.887	3.920
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Evaluate the most promising navigation instrumentation technologies and integrate the advanced gyro and accelerometer systems into a breadboard demonstration of a reduced size and reduced power navigation instrument system that approaches or exceeds ballistic missile mission goals.			
(U) In FY 2005: Downselect to the most advanced navigational instrumentation designs for the next generation of ballistic missiles. Evaluate the designs and provide improvements to meet the established performance goals. Demonstrate and validate improved navigational technology designs that can meet performance goals.			
(U)			
(U) MAJOR THRUST: Develop, integrate, and demonstrate advanced navigation technologies with new vehicle designs to provide robust, flexible, lower cost solutions for sustaining current strategic missile systems. Provide the technological base for future systems.	0.000	2.915	2.939
(U) In FY 2003: Not Applicable.			
(U) In FY 2004: Integrate advanced thermal materials into long-glide vehicles to provide greater controllability and selective targeting. Demonstrate lower-cost, robust leading edge, and control surface materials in a test flight to validate improved properties for future vehicle designs. Demonstrate that robust onboard navigation instruments and range safety devices can withstand loads greater than 100G in all axes in laboratory tests.			
(U) In FY 2005: Evaluate advanced thermal materials integrated with long-glide vehicles to provide greater controllability and selective targeting. Evaluate demonstration results of advanced leading edge and control surface			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **5083 Ballistic Missiles Technology**

materials and initiate down selection to candidates projected to provide lower cost, robust advanced future vehicle designs. Use results of laboratory testing to improve the capability of onboard navigation instruments and range safety devices to withstand loads greater than 100G in all axes in flight test demonstrations.

(U)

(U) Total Cost	0.000	6.802	6.859

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) PE 0601102F, Defense Research Sciences.									
(U) PE 0602601F, Space Technology.									
(U) PE 0603311F, Ballistic Missile Technology.									
(U) PE 0603601F, Conventional Weapons Technology.									
(U) PE 0603851F, Intercontinental Ballistic Missile-Dem/Val.									
(U) PE 0604851F, Intercontinental Ballistic Missile-EMD.									
(U) PE 0605860F, Rocket System Launch Program-Space.									
(U) This project has been coordinated through the Reliance process to harmonize efforts and eliminate duplication.									

(U) D. Acquisition Strategy

Not Applicable.

Exhibit R-2a, RDT&E Project Justification			DATE: February 2004
BUDGET ACTIVITY: 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE: 0603401F Advanced Spacecraft Technology	PROJECT NUMBER AND TITLE: 682J Spacecraft Vehicles	

Cost ($ in Millions)	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total
682J Spacecraft Vehicles	17.982	25.372	8.420	8.335	12.224	12.665	14.969	Continuing	TBD
Quantity of RDT&E Articles	0	0	0	0	0	0	0		

(U) A. Mission Description and Budget Item Justification

This project develops 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 space programs.

(U) B. Accomplishments/Planned Program ($ in Millions)	FY 2003	FY 2004	FY 2005
(U) MAJOR THRUST: 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.	1.759	2.192	2.164
(U) In FY 2003: Flight demonstrated deployment and operation of large, free-flying, lightweight, flexible, radiation resistant, array of thin film solar cells. Further integrate 32 % efficient multi-junction solar cells and 10% efficient thin film solar cells into full arrays.			
(U) In FY 2004: Demonstrate integration methods for thin-film solar cells on polymer substrates into full arrays. Complete full space qualification testing of 28% efficient solar cells.			
(U) In FY 2005: Demonstrate methods for interconnecting thin-film solar modules into array-sized thin-film blankets. Integrate 28% efficient lattice-mismatch multi-junction solar cells into test coupons.			
(U)			
(U) MAJOR THRUST: Develop innovative space conventional energy storage technologies such as the lightweight flywheel integrated power and attitude control system.	0.888	0.000	0.000
(U) In FY 2003: Flight demonstrated integrated attitude control and energy storage system. Developed microflywheel demonstration system.			
(U) In FY 2004: Not Applicable.			
(U) In FY 2005: Not Applicable.			
(U)			
(U) MAJOR THRUST: Develop technologies for long life, efficient, low vibration, lightweight mechanical cryocoolers for space applications.	1.332	1.348	1.274
(U) In FY 2003: Developed 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.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **682J Spacecraft Vehicles**

(U) In FY 2004: Investigate protoflight development of high capacity, multi-stage, low temperature cryocooler system. Develop and characterize performance of second generation design model high capacity 10 Kelvin cryocooler for advanced space surveillance and tracking sensor. Explore development of component cryocooler technologies for regenerative and recuperative cycle devices to transition enabling technology to protoflight cryocooler designs.			
(U) In FY 2005: Refine protoflight development of high capacity, multi-stage, low temperature cryocooler technologies to meet the needs of high resolution, space-based infrared surveillance and tracking sensors with larger focal planes and optics. Expand development of component cryocooler technologies for regenerative and recuperative cycle devices to transition enabling technology to protoflight cryocooler designs.			
(U)			
(U) MAJOR THRUST: Develop composites for launch vehicle and spacecraft structures and space applications, such as launch vehicle shrouds, thermal protection structures, and space antennas.	1.273	3.900	1.585
(U) In FY 2003: Developed spacecraft design to demonstrate multifunctional structures technologies. Completed evaluation of operational grid stiffened structures. Fabricated multifunctional spacecraft bus for small satellites. Completed ground test of full-scale Evolved Expendable Launch Vehicle secondary payload adapter structure.			
(U) In FY 2004: Refine spacecraft to demonstrate multifunctional structures technologies. Complete fabrication of multifunctional spacecraft bus components for small satellites. Flight qualify full-scale Evolved Expendable Launch Vehicle secondary payload adapter. Explore the design and characterize linerless composite cryogenic tanks. Develop large deployable optics structures using nanotechnology-enhanced materials.			
(U) In FY 2005: Further refine spacecraft to demonstrate multifunctional structures technologies. Ground demonstrate sub-scale linerless composite cryogenic tanks. Fabricate and characterize components for large deployable optics systems using nanotechnology-enhanced materials.			
(U)			
(U) MAJOR THRUST: 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.	3.540	7.026	3.397
(U) In FY 2003: Developed launch vibration isolation and primary and secondary payload isolation systems to meet specific launch vehicle requirements. Flight demonstrated smart passive payload isolation systems. Ground demonstrated operational active acoustic attenuation system. Flight demonstrated passive acoustic attenuation system. Integrated low shock separation devices into multiple payload adapter. Ground demonstrated smart docking and deployment mechanisms. Completed development of modular vibration-isolating spacecraft transport container.			
(U) In FY 2004: Refine launch vibration isolation and primary and secondary payload isolation systems to meet specific launch vehicle requirements. Flight demonstrate operational active acoustic attenuation systems. Flight demonstrate low-shock multiple payload adapter technologies. Build deployment and isolation mechanisms for large free-flying solar array and integrate with thin-film solar cell components. Design flight hardware to demonstrate smart docking			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY **03 Advanced Technology Development (ATD)**	PE NUMBER AND TITLE **0603401F Advanced Spacecraft Technology**	PROJECT NUMBER AND TITLE **682J Spacecraft Vehicles**

	and deployment mechanisms. Ground demonstrate full multi-axis flywheel attitude control system with integrated energy storage. Develop micro-electro-mechanical attitude control components.			
(U)	In FY 2005: Further refine launch vibration isolation and primary and secondary payload isolation systems to meet specific launch vehicle requirements. Complete development of operational active acoustic attenuation systems. Complete development of low-shock multiple payload adapter technologies. Perform flight qualification testing of smart docking and deployment hardware. Characterize performance of full multi-axis flywheel attitude control system with integrated energy storage. Integrate micro-electro-mechanical attitude control components with conventional attitude control systems.			
(U)				
(U)	CONGRESSIONAL ADD: Thin Amorphous Solar Arrays.	6.772	4.660	0.000
(U)	In FY 2003: Developed amorphous silicon solar cells for higher performance, next-generation flexible, thin film solar arrays. These thin film arrays will be three to five times lighter, cost five times less, require five times less stowed volume, and be more radiation resistant than state-of-the-art rigid panel arrays. Increased specific power (Watts/kg) of amorphous silicon solar cells by increasing cell efficiency and developing processes to deposit solar cells on lightweight polymer substrates. Developed monolithic integration technology for the low-cost interconnection of thin film solar cells.			
(U)	In FY 2004: Develop monolithic integration technology for the low-cost interconnection of thin-film amorphous silicon solar cells. Develop lightweight solar array support structures and deployment mechanisms enabled by the thin-film solar cells. Demonstrate the reproducible manufacture of large-area amorphous silicon cells necessary for population of the thin-film solar arrays.			
(U)	In FY 2005: Not Applicable.			
(U)				
(U)	CONGRESSIONAL ADD: Robust Aerospace Composite Materials/Structures.	2.418	2.776	0.000
(U)	In FY 2003: Developed a new generation of advanced composite materials to support improved manufacturing techniques for low-cost, lightweight spacecraft adapter and fairing designs. Composite materials decrease primary structure mass and cost by 40% and decrease manufacturing lead times by 50% over conventional metallic structures. Assessed material properties and identify suitable epoxy and fiber materials for spacecraft adapter and fairing applications. Developed procedures to flight qualify suitable materials and confirmed unique manufacturing processes. Fabricated and tested candidate materials identified as viable candidates.			
(U)	In FY 2004: Further develop efforts to develop larger fairings for expendable rockets. This effort focuses on the development of design, analysis, and fabrication techniques that enable larger fairings to be developed than are possible with existing technology. Specifically, this effort will refine the design, analysis, and fabrication techniques for very large payload fairings through the development of sub-scale components and test articles.			
(U)	In FY 2005: Not Applicable.			

Exhibit R-2a, RDT&E Project Justification		DATE February 2004
BUDGET ACTIVITY 03 Advanced Technology Development (ATD)	PE NUMBER AND TITLE 0603401F Advanced Spacecraft Technology	PROJECT NUMBER AND TITLE 682J Spacecraft Vehicles

(U)				
(U)	CONGRESSIONAL ADD: Boron Energy Cell Development.	0.000	3.470	0.000
(U)	In FY 2003: Not Applicable.			
(U)	In FY 2004: Increase energy conversion efficiency of the Boron Energy Cell, which converts radioisotope beta emissions into electric current. Quantify mission impacts for Department of Defense applications.			
(U)	In FY 2005: Not Applicable.			
(U)	Total Cost	17.982	25.372	8.420

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

	FY 2003 Actual	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	Cost to Complete	Total Cost
(U) Related Activities:									
(U) PE 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.