Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Air Force										DATE: February 2010	
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*				R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*							
COST ($ in Millions)	**FY 2009 Actual**	**FY 2010 Estimate**	**FY 2011 Base Estimate**	**FY 2011 OCO Estimate**	**FY 2011 Total Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
Total Program Element	136.072	119.125	111.857	0.000	111.857	117.238	117.382	122.143	128.614	Continuing	Continuing
621010: *Space Survivability & Surveillance*	48.855	52.983	48.216	0.000	48.216	46.479	43.864	44.915	45.815	Continuing	Continuing
624846: *Spacecraft Payload Technologies*	26.837	15.797	20.299	0.000	20.299	20.251	19.990	20.188	18.343	Continuing	Continuing
625018: *Spacecraft Protection Technology*	6.687	7.992	7.556	0.000	7.556	9.006	13.287	13.338	13.156	Continuing	Continuing
628809: *Spacecraft Vehicle Technologies*	53.693	42.353	35.786	0.000	35.786	41.502	40.241	43.702	51.300	Continuing	Continuing

A. Mission Description and Budget Item Justification

This PE focuses on four major areas. First, space environmental protection develops technologies to understand, mitigate, and exploit effects of weather and geophysics environments on the design and operation of Air Force systems. Second, spacecraft payload technologies improve satellite payload operations by investigating advanced component and subsystem capabilities. Third, spacecraft protection develops technologies for protecting U.S. space assets in potential hostile settings. The last major area, spacecraft vehicles, focuses on spacecraft platform, payload, and control technologies, and their interactions. This program is in Budget Activity 2, Applied Research, since it develops and determines the technical feasibility and military utility of evolutionary and revolutionary space technologies.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Air Force	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602601F: *Space Technology*

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	138.980	104.148	0.000	0.000	0.000
Current President's Budget	136.072	119.125	111.857	0.000	111.857
Total Adjustments	-2.908	14.977	111.857	0.000	111.857
• Congressional General Reductions		0.000			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	0.000	-0.503			
• Congressional Adds		15.480			
• Congressional Directed Transfers		0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• Other Adjustments	-2.908	0.000	111.857	0.000	111.857

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2009	FY 2010
Project: 621010: *Space Survivability & Surveillance*		
Congressional Add: *Nuclear Test Seismic Research/AFRL Seismic Research Program.*	1.995	4.979
Congressional Add Subtotals for Project: 621010	1.995	4.979
Project: 624846: *Spacecraft Payload Technologies*		
Congressional Add: *Field Programmable Gate Arrays/ Field Programmable Gate Arrays Mission Assurance Center.*	2.992	0.000
Congressional Add: *Radiation Hardened Non-Volatile Memory Technology.*	1.596	0.000
Congressional Add: *Reconfigurable Electronic and Non-Volatile Memory Research.*	1.995	0.797
Congressional Add Subtotals for Project: 624846	6.583	0.797
Project: 625018: *Spacecraft Protection Technology*		
Congressional Add: *Defensive Counterspace Testbed.*	0.798	0.000
	0.798	0.000

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Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2009	FY 2010
Congressional Add Subtotals for Project: 625018		
Project: 628809: *Spacecraft Vehicle Technologies*		
Congressional Add: *Multicontinuum Technology for Space Structures.*	2.872	0.000
Congressional Add: *Shielding Rocket Payloads.*	0.399	0.000
Congressional Add: *Center for Responsive Space Systems.*	0.798	0.000
Congressional Add: *Lightweight, High-Efficiency Solar Cells for Spacecraft.*	0.798	0.000
Congressional Add: *Massively Parallel Optical Interconnects for MicroSatellite Applications.*	1.596	0.000
Congressional Add: *Center for Solar Electricity and Hydrogen.*	3.590	3.983
Congressional Add: *Advanced Modular Avionics for Operationally Responsive Space Use/Advanced Modular Avionics for Operationally Responsive Satellite Use.*	2.394	2.470
Congressional Add: *Center for Space Entrepreneurship.*	0.000	1.593
Congressional Add: *Mission Design and Analysis Tool.*	0.000	1.593
Congressional Add Subtotals for Project: 628809	12.447	9.639
Congressional Add Totals for all Projects	21.823	15.415

Change Summary Explanation

The FY 2010 President's Budget submittal did not reflect FY 2011 through FY 2015 funding. A detailed explanation of changes between the two budget positions is not provided because it cannot be made in a relevant manner.

Note: In FY 2010, Congress added $2.48 million for Advanced Modular Avionics for Operationally Responsive Satellite Use, $4.0 million for the Center for Solar Electricity and Hydrogen, $1.6 million for the Center for Space Entrepreneurship, $1.6 million for Mission Design and Analysis Tool, $5.0 million for AFRL Seismic Research Program, and $0.8 million for Reconfigurable Electronics and Non-Volatile Memory Research.

C. Performance Metrics.
(U) Under Development.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*	PROJECT 621010: *Space Survivability & Surveillance*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
621010: *Space Survivability & Surveillance*	48.855	52.983	48.216	0.000	48.216	46.479	43.864	44.915	45.815	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Develop technologies for specifying, monitoring, predicting, and controlling space environmental conditions hazardous to Department of Defense (DoD) operational space systems.	8.767	8.079	8.800	0.000	8.800
FY 2009 Accomplishments: In FY 2009: Provided scientific and technical support for both optical and radio parts of solar environmental observing network replacement program. Explored techniques for measuring coronal and interplanetary magnetic fields using new wide-field radio arrays. Tested and evaluated empirical flare prediction models based on synoptic data from Air Force and national observatory assets. Coupled radiation belt model to global geospace environment models to increase accuracy and lead time. Utilized three-dimensional global radiation belt diffusion models to simulate global effect of wave-particle interactions from very low frequency (VLF) electromagnetic wave power injected in narrow altitude slices of radiation belts. Validated models for virtual VLF electromagnetic wave generation in the ionosphere and global transport and power distribution.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: In FY 2010: Complete trade studies for measuring coronal and interplanetary magnetic fields using new wide-field radio arrays. Assimilate solar vector magnetic field data into solar wind forecast models. Complete development of empirical flare prediction models and start development of physics-based flare forecast models. Analyze energetic particle measurements by recently launched sensors to understand the dynamics of the radiation belts and improve accuracy of space environment specification and forecast models. Begin investigation of new technologies for simulation and mitigation of hazards due to spacecraft electrostatic charging and discharging. Develop the reentry radar profile simulation by collecting data from re-entry vehicle test programs. Upgrade plasma effects simulation upgrade by validating code with flight data. *FY 2011 Base Plans:* In FY 2011: Develop improved solar energetic particle models. Continue development from empirical to physics-based flare forecast models. Complete validation of energetic particle measurements in multiple orbital regimes. Incorporate new simulation technologies into model of spacecraft electromagnetic and plasma environment. Validate reentry radar profile simulation using flight data. Complete plasma effects simulation with upgraded solvers, high performance computing capability, and streamlined user interface. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop spectral signature libraries, target detection techniques, and decision aids for application to space-based sensors and surveillance systems. *FY 2009 Accomplishments:* In FY 2009: Finalized brassboard hypertemporal (HT) sensor for space-based missile launch detection. Incorporated latest real-time HT processing algorithms into sensor platform. Transitioned brassboard sensor and algorithms to customer for space-based missile launch detection. Tested	14.291	15.145	12.854	0.000	12.854

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
feasibility of HT applications for technical intelligence from ground, air, and space-based platforms. Defined the requirements and configuration of a space-based HT sensor. Developed end-to-end simulation capability, based on the sensor performance models, to assist acquisition community and space operator community in trade space analyses of sensors or sensor suites. The emphasis was on the capabilities to derive information and intelligence about space objects with signals in all bands and all temporal regimes. Investigated spectral applications for material identification in support of military chemical/biological weapons detection and identification in the thermal infrared and other bands. Completed transition of spectral image processing and exploitation algorithms and related signature databases to government users. Completed analysis and documentation of military utility of planned space demonstrations of spectral theater surveillance and area search missions. Completed validation of hyperspectral models. *FY 2010 Plans:* In FY 2010: Demonstrate aircraft-based detection of large booster missile launch through optically thick sunlit clouds using existing HT image processing. Start focused effort on thermal atmospheric model validation and inversion. Initiate the development of sensor system to characterize space object orbital maneuver based on propulsion signatures. With trade space analyses, downselect and develop technical specification of space-based multi-phenomenology Space Situational Awareness (SSA) sensor payload. Document final results from space experiments in reflective spectral tests. Initiate thermal infrared (IR) imaging spectrometer feasibility for space missions. Employ and refine existing spectral radiative transfer models to evaluate requirements of space-based thermal IR imaging spectrometer to meet anticipated mission needs. *FY 2011 Base Plans:* In FY 2011: Prepare to demonstrate space-based detection of large booster missile launch through optically thick sunlit clouds using existing satellite asset and HT imaging processing. Conduct critical test of maneuver characterization sensor system with go-no-go decision point. Initiate the development of multi-phenomenology SSA sensor system for space-based SSA. Continue study of					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
thermal IR imaging spectrometer feasibility for space missions. Build and validate robust spectral radiative transfer models to evaluate requirements of space based thermal infrared IR imaging spectrometer to meet mission requirements. Continue focused effort on thermal atmospheric model validation and inversion. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop AI techniques, forecasting tools, and sensors for ionospheric specification and forecasting, space-based geolocation demonstrations, and determination of radar degradation. *FY 2009 Accomplishments:* In FY 2009: Investigated solar activity on enhancement of L-band scintillations to assess the support of the scintillation database and tools to military communication and navigation systems. Measured total electron content and scintillations over the African subcontinent for better defining the equatorial scintillation and Global Positioning System (GPS) error environment in the middle-eastern region. Delivered ionospheric compensation technique with wide-band radio-frequency waves. Improved modeling techniques for specifying high temporal resolution of neutral density and satellite drag to achieve predictive SSA. Improved empirical neutral density model based on atmospheric density specification experiment data and developed physics-based neutral modeling including composition, and density. Transitioned physics-based 3-D model of equatorial plasma bubbles into warfighter products and incorporated ionospheric Kalman filter operational models into equatorial models. *FY 2010 Plans:* In FY 2010: Develop more capable, less costly ground sensors for ionospheric electron density and scintillation parameters utilizing software digital radio technology and newly available satellite signals. Validate Communications/Navigation Outage Forecasting System (C/NOFS) instruments and products for operational uses. Implement semi-empirical high-latitude model to couple solar storm effects to the low latitude ionosphere to improve scintillation forecasts. Assess ionospheric effects on the	7.410	9.598	9.115	0.000	9.115

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
performance of lower frequency space-radar applications such as synthetic aperture radar imagery and coherent-change detection during solar maximum conditions. Quantify the requirements for coupled models. Document improved methods for tailoring the propagation environment (scintillation, scattering, etc.) using the High-frequency Active Auroral Research Program (HAARP) facilities. Validate scintillation and electron density profiles from radio occultation techniques for operational algorithm development. Expand ground-based sensor network to remote areas supporting research goals and tactical operations. Begin development of SSA testbed. *FY 2011 Base Plans:* In FY 2011: Deliver validated algorithm to simulate ionospheric effects on wideband radio frequency waveforms for arbitrary propagation paths to support many applications, including impacts on space-radar for coherent change detection. Improve assimilative ionospheric nowcast models and identify deficiencies in forecast models. Deliver physics-based equatorial scintillation forecast code for operations, derived from C/NOFS Advanced Concept Technology Demonstration. Test physics-based neutral density models forecasting capabilities, particularly during magnetic storms. Deliver algorithm for estimating ionospheric-errors on dual-frequency GPS systems for DoD applications; identify appropriate path for integrating into operations. Derive algorithm for nowcast scintillation from space-based occultation techniques. Begin deployment of improved ground sensors to reduce support costs of ground-station network. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop HAARP site transmitting and diagnostic instrument infrastructure. Note: In FY 2011, emphasis is place on radiation belt remediation technologies.	9.703	9.225	11.059	0.000	11.059

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: In FY 2009: Continued research to characterize wave-particle interactions and wave amplification effects in space and their potential application to mitigate charged particle effects on space systems and operations. *FY 2010 Plans:* In FY 2010: Enhance wave-particle interactions and amplification research their application to mitigate charged particle effects on space systems and operations with coordinated Demonstration and Science Experiment (DSX) satellite studies and feedback from physical models. *FY 2011 Base Plans:* In FY 2011: Initiate research programs to develop controlled processes of triggered optical and infrared emissions and radio scintillation for potential DoD applications. Develop experiment using Demonstration and Science Experiment satellite and HAARP based on studies and feedback from physical models. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop seismic technologies to support national requirements for monitoring nuclear explosions with special focus on regional distances less than 2,000 kilometers from the sensors. *FY 2009 Accomplishments:* In FY 2009: Developed different techniques for automated processing of increasing numbers of seismic events. Conducted detailed research on causes of challenges in high-frequency regional discrimination. Continued efforts on seismic calibration; seismic detection, location, and discrimination; and observational studies of seismic wave propagation, including propagation in Eurasia. Conducted detailed studies of particular challenge areas in local seismic monitoring. Conducted design and conducted theoretical, laboratory, and field studies to support local monitoring.	6.689	5.957	6.388	0.000	6.388

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: In FY 2010: Refine and expand the applicability of different techniques for automated processing of increasing numbers of seismic events. Continue to conduct detailed research on causes of challenges in high-frequency regional discrimination. Integrate results of seismic calibration and observational studies of seismic wave propagation, including propagation in Eurasia, into a unified model. Continue to conduct detailed studies of particular challenge areas in local seismic monitoring. Continue to conduct theoretical, laboratory, and field studies to support local monitoring of new targets. Continue to study improvements in seismic detection, location, and discrimination. *FY 2011 Base Plans:* In FY 2011: Test and implement refined techniques for automated processing of increasing numbers of seismic events. Evaluate causes of challenges in high-frequency regional discrimination. Test and refine unified model results of seismic calibration and observational studies of seismic wave propagation, including propagation in Eurasia. Continue to conduct detailed studies of particular challenge areas in local seismic monitoring. Continue to conduct theoretical, laboratory, and field studies to support local monitoring of developing targets. Continue to study improvements in seismic detection, location, and discrimination. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	46.860	48.004	48.216	0.000	48.216

	FY 2009	FY 2010
Congressional Add: Nuclear Test Seismic Research/AFRL Seismic Research Program.	1.995	4.979

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
FY 2009 Accomplishments: In FY 2009: Conducted Congressionally-directed effort for Nuclear Test Seismic Research. *FY 2010 Plans:* In FY 2010: Conduct Congressionally-directed effort for AFRL Seismic Research Program.		
Congressional Adds Subtotals	1.995	4.979

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0305111F: *Weather Systems.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0305160F: *Defense Meteorological Satellite Program.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0601102F: *Defense Research Sciences.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602204F: *Aerospace Sensors.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0603401F: *Advanced Spacecraft Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
624846: *Spacecraft Payload Technologies*	26.837	15.797	20.299	0.000	20.299	20.251	19.990	20.188	18.343	Continuing	Continuing

Note

Note: In FY 2011, increases in funding are due the movement of technologies from PE 0603401F, Advanced Spacecraft Technology, to this PE in order to better align the technology readiness levels of these efforts.

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Develop advanced infrared device technologies that enable hardened space detector arrays with improved detection to perform acquisition, tracking, and discrimination of space objects.	4.961	3.140	4.207	0.000	4.207
FY 2009 Accomplishments: In FY 2009: Investigated spectral agility. Demonstrated tuning from 8 to 12 microns in 1 micron increments. Investigated field enhancement technologies. Demonstrated optical amplification using quantum interference and demonstrated enhancement using plasmons. Investigated the single pixel polarimeter. Demonstrated improved long-wave infrared (LWIR) superlattice detector and assessed very long-wave infrared feasibility.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: In FY 2010: Expand investigation of spectral agility to longer wavelengths. Expand investigation of field enhancement technologies. Complete final demonstration of optical amplification using quantum interference. *FY 2011 Base Plans:* In FY 2011: Demonstrate tuning from 15 to 20 microns in 1 micron increments. Demonstrate field enhancement technology. Complete predictive capability for next generation of large format technology challenges. Initiate predictive capability for next generation of large format detector array and readout array technology challenges. Begin space object remote characterization study. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop spectral sensing and data exploitation methodologies for military imaging and remote sensing applications. *FY 2009 Accomplishments:* In FY 2009: Completed the development and initiated the validation of a predictive model for advanced imaging. Validated model against laboratory and available field data of intelligence, surveillance, and reconnaissance (ISR) and SSA missions. Made improvements to the simulation capability to improve accuracy and usability of the model. Utilized the prediction capability to develop concepts for purpose built sensors for SSA. *FY 2010 Plans:* In FY 2010: Complete validation of advanced imaging technology predictive models for SSA concepts of operation. Continue to advance simulation capability to enhance accuracy and usability of these models.	2.999	3.807	5.485	0.000	5.485

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: In FY 2011: Further refine models for space-based spectral imaging to include additional space-based situational awareness imaging concepts and operationally responsive SSA scenarios. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop technologies for space-based payload components such as radiation-hardened electronic devices, micro-electro-mechanical system devices, and advanced electronics packaging. *FY 2009 Accomplishments:* In FY 2009: Completed the current Satellite Design Automation software evolution to a logical "push-button toolflow" satellite builder. Demonstrated radiation-harden space sensor interface modules allocating standardized data message protocols from sensors for easy device control of sensors and actuators. *FY 2010 Plans:* In FY 2010: Initiate study of phase change materials and begin to develop new classes of electronics that enable efficient analog computing. Develop methods of hardening generation-after-next electronic devices that enable a factor of two increase in computing performance. Investigate the operation of nanoelectronic devices and incorporate those into new classes of detectors and transistors to enable terahertz operation. Initiate the study of thermoelectric cooling based on advanced Peltier effect materials. Initiate development of radiation hardened plug-and-play interface module to support rapid development or reconfiguration of spacecraft hardware. *FY 2011 Base Plans:* In FY 2011: Apply the basic physical understanding of the operation of phase change materials to analog computing and device trimming applications. Transition radiation mitigation processes using minimally invasive techniques into libraries at major commercial foundries at the 95 nanometer (nm)	4.160	3.392	5.241	0.000	5.241

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and 65nm nodes. Characterize the reliability and suitability of devices made with advanced gate insulator materials and provide the findings to industry. Apply the understanding of quantum based field effect transistors to commercial foundries. Initiate program to capitalize on high performance thermoelectric cooling devices applied to focal plane arrays. Continue development of radiation hardened plug-and-play interface module, including fabrication of engineering model interface modules, to support rapid development or reconfiguration of spacecraft hardware. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: M&S tools for space-based ground surveillance systems, rendezvous and proximity operations, imaging of space systems, distributed satellite architecture, and space control payloads. *FY 2009 Accomplishments:* In FY 2009: Developed engineering, military utility, and cost models for space superiority analysis of SSA detection capabilities. Developed a simulation repository capability for the distributed architecture simulation lab. Developed first-generation decision support tools for space superiority. Developed confidence metrics and software system testbed to score developed tools. *FY 2010 Plans:* In FY 2010: Complete SSA detection analysis tools and begin developing engineering and military utility models for object identification to support SSA and defensive space control (DSC). Incorporate additional tools from external and external sources. Validate tools and code in the simulation repository. Continue development of first-generation decision support tools for space superiority. Finalize software system testbed. Begin testing of tools on testbed. Begin development of resource management tools for space superiority.	4.622	4.191	4.481	0.000	4.481

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: In FY 2011: Refine detection and identification tools for modeling, simulation, and analysis. Begin development of engineering, military utility, and cost tools that model object characterization for space superiority analysis of SSA and DSC technologies. Integrate data from flight experiments to refine simulations. Finish development of first-generation decision support tools for space superiority. Expand testbed to include resource management testing capability. Continue development of resource management tools for space superiority. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop technologies for next-generation space communications terminals and equipment and methods/techniques to enable future space system operational command and control concepts. *FY 2009 Accomplishments:* In FY 2009: Performed study of future communication requirements. Developed subsystems for testing and performance enhancements experiments. *FY 2010 Plans:* In FY 2010: Begin development of engineering model of critical technology to satellite communication and ground terminals. *FY 2011 Base Plans:* In FY 2011: Complete engineering model and select technology for space experiment on enhanced communication platform. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A	3.512	0.470	0.885	0.000	0.885

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*	PROJECT 624846: *Spacecraft Payload Technologies*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Accomplishments/Planned Programs Subtotals	20.254	15.000	20.299	0.000	20.299

	FY 2009	FY 2010
Congressional Add: Field Programmable Gate Arrays/ Field Programmable Gate Arrays Mission Assurance Center. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Field Programmable Gate Arrays Mission Assurance Center. *FY 2010 Plans:* In FY 2010: Not Applicable.	2.992	0.000
Congressional Add: Radiation Hardened Non-Volatile Memory Technology. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Radiation Hardened Non-Volatile Memory Technology. *FY 2010 Plans:* In FY 2010: Not Applicable.	1.596	0.000
Congressional Add: Reconfigurable Electronic and Non-Volatile Memory Research.	1.995	0.797

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*	PROJECT 624846: *Spacecraft Payload Technologies*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
FY 2009 Accomplishments: In FY 2009: Conducted Congressionally-directed effort for Reconfigurable Electronic and Non-Volatile Memory Research. *FY 2010 Plans:* In FY 2010: Conduct Congressionally-directed effort for Reconfigurable Electronic and Non-Volatile Memory Research.		
Congressional Adds Subtotals	6.583	0.797

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0603401F: *Advanced Spacecraft Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

D. Acquisition Strategy

Not Applicable.

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*	PROJECT 625018: *Spacecraft Protection Technology*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
625018: *Spacecraft Protection Technology*	6.687	7.992	7.556	0.000	7.556	9.006	13.287	13.338	13.156	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Develop satellite threat warning technologies and tools for space defense. Exploit on-board inherent satellite resources, satellite-as-a-sensor, and self-aware satellite technologies.	5.889	7.992	7.556	0.000	7.556
FY 2009 Accomplishments: In FY 2009: Developed an active and/or passive threat warning sensor for detection of a direct assent or co-orbital vehicle and transitioned these engineering designs. Identified potential technology options that could provide defensive capability for incorporation into geosynchronous orbit/low earth orbit satellites and completed engineering designs.					
FY 2010 Plans: In FY 2010: Explore capabilities of potential defensive subsystems through laboratory testing. Identify likely transition opportunities and prepare engineering models to assess performance. Develop techniques to exploit existing satellite sensors for defense.					
FY 2011 Base Plans: In FY 2011: Complete laboratory testing of potential defensive subsystems. Develop performance goals using engineering models. Transition dual usage sensor technology to multiple satellite					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*	PROJECT 625018: *Spacecraft Protection Technology*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
systems. Identify emerging opportunities to develop/expand defensive subsystems for additional users. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	5.889	7.992	7.556	0.000	7.556

	FY 2009	FY 2010
Congressional Add: Defensive Counterspace Testbed. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Defensive Counterspace Testbed. *FY 2010 Plans:* In FY 2010: Not Applicable.	0.798	0.000
Congressional Adds Subtotals	0.798	0.000

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0603401F: *Advanced Spacecraft Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

D. Acquisition Strategy

Not Applicable.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602601F: *Space Technology*	**PROJECT** 625018: *Spacecraft Protection Technology*

E. Performance Metrics

Please refer to the Performance Base Budget Overview Book for information on how Air Force resources are applied and how those resources are contributing to Air Force performance goals and most importantly, how they contribute to our mission.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force			DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*	PROJECT 628809: *Spacecraft Vehicle Technologies*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
628809: *Spacecraft Vehicle Technologies*	53.693	42.353	35.786	0.000	35.786	41.502	40.241	43.702	51.300	Continuing	Continuing

Note

Note: In FY 2011, increases in funding are due to realignment of technologies from PE 0603401F, Advanced Spacecraft Technology, to this PE in order to better align the technology readiness levels of these efforts.

A. Mission Description and Budget Item Justification

This project focuses on three major space technology areas: spacecraft platforms (e.g., structures, controls, power, and thermal management); satellite control (e.g., signal processing and control); and space experiments of maturing technologies for space qualification.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
MAJOR THRUST: Develop technologies for advanced space platform subsystems such as cryocoolers, compact, high efficiency solar power cells and arrays, and innovative power generation concepts.	4.164	4.743	4.792	0.000	4.792

FY 2009 Accomplishments:

In FY 2009: Refined and validated cryocooler component and system models with experimental data. Investigated thermodynamic loss mechanisms in regenerative cycle cryocoolers through computational fluid dynamics models. Completed design work for improved short-wavelength infrared/ medium-wavelength infrared (SWIR/MWIR) cryocooler application for missile launch detection and technical intelligence mission systems. Completed engineering demonstration of advanced array for thin-film solar cells scaleable to greater than 100 kilowatts (kw).

FY 2010 Plans:

In FY 2010: Continue to refine and validate cryocooler component and system models with experimental data. Complete models/validation of pulse tube and start models/validation of inertance

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*	PROJECT 628809: *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
tube, regenerator and compressor. Continue to investigate thermodynamic loss mechanisms in regenerative cycle cryocoolers through computational fluid dynamics models, including two-stage pulse-tube cryocoolers and multistage coolers from 110 degrees Kelvin to 10 degrees Kelvin. Develop subcell technology for thin-film tandem solar cell traceable to greater than 20% efficiency. Continue development of material growth and device structures for solar cells traceable to 40% or higher ultra-high efficiency solar cells. *FY 2011 Base Plans:* In FY 2011: Complete cryocooler component and system models with experimental data, and begin to analyze cryocoolers as a single unit. Correlate thermodynamic loss mechanisms in regenerative cycle cryocoolers through computational fluid dynamics models, including two-stage pulse tube cryocoolers and multistage coolers from 110 degrees Kelvin to 10 degrees Kelvin to experimental results. Begin to develop full-scale design equations for cryocoolers, increasing efficiency by 20% and decreasing manufacturing time by 200%. Demonstrate integrated, monolithic thin-film tandem solar cell. Demonstrate subcomponents of ultra high efficiency solar cell. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop technologies for advanced space platform structures. *FY 2009 Accomplishments:* In FY 2009: Developed multifunctional structural hardware concepts for SSA, such as structural health monitoring, light occultation by nearby objects, and detection of radio frequency (RF) emissions. Developed system-level architectures for large precision deployable structures. Developed advanced estimation algorithms for better local situational awareness using existing and next-generation hardware, such as star-trackers for object detection, characterization, and tracking.	14.286	12.565	16.906	0.000	16.906

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: In FY 2010: Continue development of system-level deployable structures for RF frequencies. Initiate development of integrated thermal management subsystems for responsive space class of satellites. Finish and transition advanced estimation algorithms for local situational awareness for next-generation systems. Begin development of guidance, navigation, and control algorithms built around rapid integration and test of satellite hardware. Begin development of advanced data association algorithms for space object tracking. Build representative test cases for data association algorithms. Initiate development of modular plug-and-play spacecraft structural panels to address such concerns as rapid assembly, thermal management, and built-in harnesses and electronics. *FY 2011 Base Plans:* In FY 2011: Continue development of integrated thermal management subsystems for responsive space class of satellites. Initiate the development of nano-reinforced structures for space applications. Continue development of advanced guidance, navigation and control algorithms for rapid integration and test of satellite hardware. Continue development of data association tools for space object tracking. Begin development of autonomous guidance, navigation, and control algorithms for proximity operations. Continue development of modular plug-and-play spacecraft structural panels, including fabrication of engineering model panels, to address such concerns as rapid assembly, thermal management, and built-in harnesses and electronics. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
MAJOR THRUST: Develop flight experiments to improve the capabilities of existing operational space systems and to enable new transformational space capabilities.	22.796	15.406	14.088	0.000	14.088

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: In FY 2009: Continued ground-based experiments supporting the Demonstration and Science Experiments (DSX) satellite. Delivered host DSX spacecraft bus. Began integration and test of DSX payloads. Continued development of ground support equipment and software. *FY 2010 Plans:* In FY 2010: Continue ground-based experiments. Begin DSX system-level integration and test. Complete DSX payload system-level functional and environmental tests. Continue development of ground support equipment and software. *FY 2011 Base Plans:* In FY 2011: Continue ground-based experiments in support of radiation belt remediation technologies. Complete DSX and payload integration and functional/environmental testing for radiation belt remediation payload. Complete development of ground support equipment and software. *FY 2011 OCO Plans:* In FY 2011 OCO: N/A					
Accomplishments/Planned Programs Subtotals	41.246	32.714	35.786	0.000	35.786

	FY 2009	FY 2010
Congressional Add: Multicontinuum Technology for Space Structures. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Multicontinuum Technology for Space Structures.	2.872	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
FY 2010 Plans: In FY 2010: Not Applicable.		
Congressional Add: Shielding Rocket Payloads. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Shielding Rocket Payloads. *FY 2010 Plans:* In FY 2010: Not Applicable.	0.399	0.000
Congressional Add: Center for Responsive Space Systems. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Center for Responsive Space Systems. *FY 2010 Plans:* In FY 2010: Not Applicable.	0.798	0.000
Congressional Add: Lightweight, High-Efficiency Solar Cells for Spacecraft. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Lightweight, High-Efficiency Solar Cells for Spacecraft. *FY 2010 Plans:* In FY 2010: Not Applicable.	0.798	0.000
	1.596	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Air Force		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602601F: *Space Technology*	PROJECT 628809: *Spacecraft Vehicle Technologies*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Massively Parallel Optical Interconnects for MicroSatellite Applications. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Massively Parallel Optical Interconnects for MicroSatellite Applications. *FY 2010 Plans:* In FY 2010: Not Applicable.		
Congressional Add: Center for Solar Electricity and Hydrogen. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Center for Solar Electricity and Hydrogen. *FY 2010 Plans:* In FY 2010: Conduct Congressionally-directed effort for Center for Solar Electricity and Hydrogen.	3.590	3.983
Congressional Add: Advanced Modular Avionics for Operationally Responsive Space Use/Advanced Modular Avionics for Operationally Responsive Satellite Use. *FY 2009 Accomplishments:* In FY 2009: Conducted Congressionally-directed effort for Advanced Modular Avionics for Operationally Responsive Space Use. *FY 2010 Plans:* In FY 2010: Conduct Congressionally-directed effort for Advanced Modular Avionics for Operationally Responsive Satellite Use.	2.394	2.470
Congressional Add: Center for Space Entrepreneurship.	0.000	1.593

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
FY 2009 Accomplishments: In FY 2009: Not Applicable. *FY 2010 Plans:* In FY 2010: Conduct Congressionally-directed effort for Center for Space Entrepreneurship.		
Congressional Add: Mission Design and Analysis Tool. *FY 2009 Accomplishments:* In FY 2009: Not Applicable. *FY 2010 Plans:* In FY 2010: Conduct Congressionally-directed effort for Mission Design and Analysis Tool.	0.000	1.593
Congressional Adds Subtotals	12.447	9.639

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• PE 0602203F: *Aerospace Propulsion.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0602102F: *Materials.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
• PE 0603401F: *Advanced Spacecraft Technology.*	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

D. Acquisition Strategy

Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY 3600: *Research, Development, Test & Evaluation, Air Force* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602601F: *Space Technology*	**PROJECT** 628809: *Spacecraft Vehicle Technologies*

E. Performance Metrics

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