RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2006	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E				
COST (In Millions)	FY 2005	FY2006	FY2007	FY 2008	FY 2009	FY 2010	FY 2011
Total Program Element (PE) Cost	217.004	216.357	254.913	294.648	317.360	328.943	334.598
Space Programs and Technology SPC-01	217.004	216.357	254.913	294.648	317.360	328.943	334.598

(U) Mission Description:

(U) The Space Programs and Technology program element is budgeted in the Advanced Technology budget activity because it addresses high payoff opportunities to dramatically reduce costs associated with advanced space systems and provides revolutionary new system capabilities for satisfying current and projected military missions.

(U) A space force structure that is robust against attack represents a stabilizing deterrent against adversary attacks on space assets. In addition to the ability to detect and characterize potential attacks, robustness against attack is provided by proliferation of assets, ready access to space, the ability to neutralize man-made space environments, and a flexible infrastructure for maintaining the capabilities of on-orbit assets. Ready access to space allows the delivery of defensive systems and replenishment supplies to orbit. An infrastructure to service the mission spacecraft allows defensive actions to be taken without limiting mission lifetime. In addition, developing space access and spacecraft servicing technologies will lead to reduced ownership costs of space systems and new opportunities for introducing technologies for the exploitation of space. Systems development is also required to increase the interactivity of space systems, space-derived information and services with terrestrial users. Studies under this project include technologies and systems that will enable satellites and microsatellites to operate more effectively by increasing maneuverability, survivability, and situational awareness; enabling concepts include solar thermal propulsion, novel ion-thruster applications, payload isolation and pointing systems.

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(U) Program Accomplishments/Planned Programs:

	FY 2005	FY 2006	FY 2007
Orbital Express Space Operations Architecture	46.599	37.271	31.711

(U) The goal of the Orbital Express Space Operations Architecture program is to validate the technical feasibility of robotic, autonomous on-orbit refueling and reconfiguration of satellites to support a broad range of future U.S. national security and commercial space programs. Refueling satellites will enable frequent maneuver to improve coverage, change arrival times to counter denial and deception and improve survivability, as well as extend satellite lifetime. Electronics upgrades on-orbit can provide regular performance improvements and dramatically reduce the time to deploy new technology on-orbit. The Orbital Express advanced technology demonstration will design, develop and test on-orbit a prototype servicing satellite (ASTRO) and a surrogate next generation serviceable satellite (NextSat). The elements of the Orbital Express demonstration, coordinated with Air Force Space Command and Air Force Space and Missile Command, will be tied together by non-proprietary satellite servicing interfaces (mechanical, electrical, etc.) that will facilitate the development of an industry wide on-orbit servicing infrastructure. NASA will apply the sensors and software developed for autonomous rendezvous and proximity operations to reduce risk for collaborative human-robotic operations in space for the NASA Exploration Initiative. Launch of the demonstration system is scheduled for September 2006 on the Air Force Space Test Program STP-1 mission.

(U) Program Plans:

- Develop and validate software for autonomous mission planning, rendezvous, proximity operations and docking.
- Design, fabricate, and test on-orbit robotic satellite servicing, including fuel and electronics transfer, deployment of and operations with a micro-satellite.
- Perform utility assessments of on-orbit servicing in conjunction with operational customers and plan for technology transition.

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	FY 2005	FY 2006	FY 2007
Space Surveillance Telescope	16.673	18.592	9.771

(U) The Space Surveillance Telescope program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. The program will leverage recent advances in curved focal plane array sensor technology to enable an innovative telescope design that combines high detection sensitivity, short focal length, wide field of view and rapid step-and-settle to provide orders of magnitude improvements in space surveillance. This capability will enable ground-based detection of un-cued objects in space for purposes such as asteroid detection and other defense missions. The Air Force will participate in the DARPA funded development testing of SST and then take over operation of SST as a sensor in the Air Force Space Surveillance Network. An MOA has been established with Air Force Space Command for transition at the conclusion of Phase II that is anticipated to be completed by FY 2009.

(U) Program Plans:
- Develop, fabricate, and integrate a mosaic of curved focal plane arrays into a wide field–of-view detector system.
- Develop, test, and validate software for autonomous telescope operations and data reporting.
- Design and fabricate telescope enclosure and supporting infrastructure at White Sands Missile Range.
- Validate end-to-end telescope performance and surveillance operations.

	FY 2005	FY 2006	FY 2007
Innovative Space-Based Radar Antenna Technology (ISAT)	45.000	45.000	50.000

(U) The Innovative Space-Based Radar Antenna Technology (ISAT) effort will develop radically new enabling technologies and design methods for extremely large space-based radio frequency (RF) antenna technologies necessary for tactical-grade ground moving target indicator (GMTI) radar. Up to 300 meters long electronically scanned antenna (ESA) designs will be developed by leveraging major advances in novel materials (such as rigidized inflatables and shape memory polymers), packing techniques and ultra lightweight low-power density RF electronics.

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An antenna of this size enables a medium earth orbit (MEO) constellation that provides 24/7 true continuous coverage with 10 to 12 satellites (about 96 satellites at low earth orbit (LEO) would be required to provide the same level of coverage). The Innovative Space-Base Radar Antenna Technology (ISAT) also enables detection and tracking of all airborne targets. The ISAT program will retire the risk associated with two major technical obstacles: 1) the reliable and controllable deployment of a ~300 meter long electronically scanned antenna (ESA) with a linear compaction ratio of 100:1; and 2) the on-orbit calibration (particularly on transmit) and control of the ISAT antenna. Novel power generation and distribution systems will also be investigated. The program will conduct ground-based risk reduction experiments demonstrating the accuracy of the constitutive models for deployment and control of large antenna structures and will also develop concepts of operations, performance predictions and lifecycle cost models for the selected designs, as well as investigate the applicability of the technologies to other missions. These designs will be down selected to carry out a space-based experiment of the critical technologies. DARPA is establishing an MOA with the Air Force for this program. The ISAT technology is planned for transition to the Air Force at the conclusion of Phase IV, which is anticipated to be completed by FY 2010.

(U) Program Plans:

- Tested the mechanical and environmental properties of materials and structural components.
- Simulated metrology and calibration approaches for large space antenna structures.
- Initiated development of next-generation lightweight electronics, materials and deployment structures.
- Design of risk reduction demo experiment.
- Perform ground-based risk reduction experiments for packaging and deployment mechanisms and materials, including simulation of mechanical and thermal loads.
- Perform ground-based risk reduction experiments of the metrology and calibration approaches in preparation for on-orbit demonstration.
- Build and perform flight demonstration of prototype system.

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	FY 2005	FY 2006	FY 2007
Novel Satellite Communications	6.208	8.500	14.575

(U) The aim of the Novel Satellite Communications (NSC) program is the development of an advanced, affordable multi-user satellite communications (SATCOM) system that allows ground-based users with handheld radios to communicate with the satellite at high data rates, even when the users are close to multiple jammers and/or located in urban (i.e. severe multi-path) settings. This will be accomplished through advanced low-weight, highly compactable antennas and novel signal processing, communications and coding techniques. The NSC technology will transition to the U.S. Navy (SPAWAR) and U.S. Air Force (SMC) following the NSC demonstration in 2008.

(U) Program plans:
- Developed novel NSC system.
- Determined feasibility of novel concepts to enable robust communications in the presence of multiple nearby jammers.
- Develop signal processing, communications and coding techniques that fully exploit the novel concepts to provide a robust anti-jam capability in the presence of multiple nearby jammers.
- Carry out proof-of-concept demonstrations.

	FY 2005	FY 2006	FY 2007
Integrated Sensor is Structure (ISIS)	(11.000)	(18.000)	16.262

(U) The ISIS program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship that will address the nation's need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly-integrated lightweight multi-purpose airship structure - completely erasing the distinction between payload and platform. The ISIS concept includes 99% on-station 24/7/365 availability for Simultaneous Airborne Moving Target Indicator (AMTI) (600 kilometers) and Ground-Based Moving Target Indicator (GMTI) (300 kilometers) operation; 12+ months of

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autonomous unmanned flight; hundreds of wideband in-theater covert communications links; plus CONUS-based sensor analysis and operation. The ISIS technology is planned for transition to the Army's PEO-Air, Space and Missile Defense (ASMD), Air Force Joint Warfighter Space and the Missile Defense Agency at the conclusion of Phase IV which is anticipated to be completed by FY 2011. This program was formerly funded under PE 0603767E, Project SEN-01.

(U) Program Plans:

- Develop objective system concept designs enabling simultaneous AMTI and GMTI operation, one year logistics-free operation, 99% on-station availability, and high-bandwidth covert communications.
- Identify specific mass-reducing technologies for key radar, power, and airship components.
- Develop and demonstrate lightweight technologies for system integration (i.e. high-energy density batteries, electronic circuits on thin-film barrier materials, advanced multi-purpose airship hulls, and regenerative fuel technologies).
- Design and simulate new radar modes: tracking air and ground targets through the clutter notch; detection and response to rockets, artillery, and mortars (RAM); detection of dismounted enemy combatants; and “track-all-the-way” fire-control.
- Design, build and demonstrate a fully-operational scaled flight system demonstrating complete system integration over an extended period (~3 months).

	FY 2005	FY 2006	FY 2007
Ground Based Imaging (GBI)	0.000	0.000	2.200

(U) The Ground Based Imaging program will develop a capability for sub-meter resolution of non-rotating objects in geostationary orbit. The technology will use a very high power, millimeter wave (W-band) frequency illuminator and a very large, coherent sparse array receiver. The overriding technical obstacle is the integration of a very large (100s of kilometers) ground-based bi-static radar system with image processing capabilities that could produce results in a timely manner. This capability will augment existing radar imaging systems that rely on object motion to generate high resolution images.

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(U) Program Plans:
- Evaluate performance capabilities versus system design parameters and component technologies.
- Prove feasibility in sub-scale tests.
- Design, build, and test prototype for space object imaging.

	FY 2005	FY 2006	FY 2007
Deep View	14.420	11.920	10.250

(U) The Deep View program will develop a high-resolution radar imaging capability to characterize objects in earth orbit. A special emphasis will be placed on imaging small objects at orbits ranging from low earth orbit (LEO) to geo-stationary orbit (GEO). The system will be based upon a large aperture imaging radar system redesigned to operate at very high power over very broad bandwidth at W-band. Key technology development will focus on: (1) transmitters capable of providing the required power to image at deep-space ranges over full bandwidth; and (2) an antenna design that maintains the necessary form factor over a very large aperture. The capabilities emerging from this program will enable the classification of unknown objects, such as space debris, as well as the monitoring of the health and status of operational satellites. DARPA established an MOA with the Air Force for this program in August 2004. The Deep View technology is planned for transition to the Air Force at the conclusion of Phase III, which is anticipated to be completed by FY 2009.

(U) Program Plans:
- Fabricate additional gyro-twystron transmitter tubes.
- Perform transmitter power combiner experiments.
- Complete transmitter design and radar system design.
- Begin antenna replacement.
- Begin signal processing software development and testing.
- Integrate into a low-power configuration in FY 2008, providing LEO-only capability.
- Demonstrate LEO-GEO imaging capability using a full set of gyro-twystrons.

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	FY 2005	FY 2006	FY 2007
Responsive Access, Small Cargo, Affordable Launch (RASCAL)	2.500	0.000	0.000

(U) The goal of the Responsive Access, Small Cargo, Affordable Launch (RASCAL) program was to develop a low cost orbital insertion capability for micro-size satellite payloads. The concept consisted of a responsive, routine, small payload delivery system capable of providing flexible access to space using a combination of reusable and low cost expendable vehicle elements. Specifically, the RASCAL system concept included a reusable airplane-like first stage vehicle called the mass injection pre-compressor cooling (MIPPC) powered vehicle (MPV) and a second and third stage expendable rocket vehicle (ERV). The RASCAL demonstration objective was to place satellites and commodity payloads, between 50 and 130 kilograms in weight, into low earth orbit at any time, with a launch cost of less than $20,000 per kilogram. While the cost goal was commensurate with current large payload launch systems, it was estimated that the operational system, through production economies of scale, would have been more than a factor of three less than current capabilities for the dedicated micro payload size. Such a capability could enable cost effective use of on-orbit replacement and re-supply and provide a means for rapid launch of orbital assets for changing national security needs. The RASCAL program will not continue into Phase III. Planned testing and experiments to demonstrate the utility of the MIPCC propulsion augmentation technology were completed in 2005. The RASCAL program has been completed.

(U) Program Plans:

- Developed Contractor Life Cycle Cost Model (CLCC).
- Selected preferred system concept.
- Conducted early Risk Reduction testing of subsystems: J-85 and F-100 turbine engine testing with MIPCC for thrust augmentation, aircraft wind tunnel for stability, aircraft engine inlet wind tunnel testing, scaled static fires of hybrid motors, Guidance, Navigation & Control (GN&C) simulation, and Reaction Control System (RCS) firing.
- Completed prototype Mass Injection Pre-Compressor Cooling (MIPCC) manifold – engine testing.

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	FY 2005	FY 2006	FY 2007
Tactically Responsive Satellites (TRS)	2.924	0.000	0.000

(U) The TRS program developed next generation satellite systems capable of on-demand deployment. Existing satellite systems require extensive time to both integrate onto launch vehicles and checkout once on orbit. This timeline, currently on the order of months (at best), needs to be shortened to days or even hours. Examples of militarily significant tactical payloads include imaging, surveillance, reconnaissance (ISR), as well as tactical communications. Rapid replenishment of space assets in the event of pre-mature failure, or worse, is a major side benefit of TRS technology. Enabling technologies that played a role in the TRS program include next generation lightweight and highly compactable aperture technologies (RF, EO/IR, optical, etc.), novel rapid checkout microsat spacecraft designs, composite bus structures, and advanced lightweight electronics. The technologies transitioned to the newly formed Air Force Tactical Satellite (TACSAT) program at the end of FY 2005.

(U) Program Plans:
- Evaluated the feasibility of candidate TRS missions.
- Developed candidate designs for tactically responsive warfighter payloads.
- Developed and matured key enabling technologies.

	FY 2005	FY 2006	FY 2007
Falcon	12.500	35.600	51.500

(U) The Falcon program objectives are to develop and demonstrate hypersonic technologies that will enable prompt global reach missions. This capability is envisioned to entail a reusable Hypersonic Cruise Vehicle (HCV) capable of delivering 12,000 pounds of payload a distance of 9,000 nautical miles from CONUS in less than two hours. The technologies required by a HCV include high lift-to-drag technologies, high temperature materials, thermal protection systems, and guidance, navigation, and control. Leveraging technology developed under the Hypersonic Flight (HyFly) program, Falcon will address the implications of hypersonic flight and reusability using a series of hypersonic technology vehicles (HTVs) to incrementally demonstrate these required technologies in flight. In order to implement this flight test program in an affordable manner,

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Falcon will develop a low cost, responsive Small Launch Vehicle (SLV) that can be launched for $5M or less. In addition to hypersonic technology vehicles (HTV) sub-orbital launches, the SLV will be capable of launching small satellites into low earth and sun-synchronous orbits and will provide the nation a new, small payload access to space capability. Thus, the Falcon program addresses many high priority mission areas and applications such as global presence and space lift. DARPA established an MOA with the Air Force for this program in May 2003 and with NASA in October 2004. Falcon capabilities are planned for transition to the Air Force at the conclusion of Phase III, which is anticipated to be completed by FY 2010.

(U) Program Plans:

- Completed preliminary design for HTV-1 technology flight demonstration vehicle.
- Conducted wind tunnel test of HTV-1 aero configuration.
- Completed SLV preliminary designs.
- Conducted SLV scaled hybrid motor firings.
- Conducted SLV propulsion injector and ablative chamber firings.
- Conducted SLV first stage static firing.
- Conducted full scale size, subscale weight, air launch drop test.
- Conduct early launch demonstrating responsive operations.
- Conducted HTV-1 critical design review and purchased long lead items.
- Conduct multiple full scale size, full scale weight air launch drop tests.
- Conduct SLV full scale engine firings.
- Conduct critical design review of HTV-2 demonstration system, and initiate fabrication.
- Conduct critical design review of SLV, and initiate fabrication.
- Initiate preliminary design of the HTV-3 technology flight demonstration vehicle.
- Conduct HTV-1 flight demonstration.
- Conduct SLV flight demonstration.
- Conduct critical design review of HTV-3 demonstration system and initiate fabrication.
- Conduct flight testing of HTV-2 incorporating next generation hypersonic technologies.
- Conduct flight-testing of advanced reusable technologies for HCV.

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	FY 2005	FY 2006	FY 2007
Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST)	6.000	2.000	0.000

(U) The goal of the Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST) program is to develop technologies to enable low-cost, responsive spacecraft and capabilities, such as space situational awareness and blue force tracking. Key payload technologies include light-weight optics, adaptive focal plane array sensors, and efficient space-qualified receivers and processors. The program focuses on technologies that will enable a spacecraft deployment from a small launch vehicle and affordable enough to be launched on-demand to support dedicated tactical mission needs in the direct control of the warfighter.

(U) Program Plans:
- Evaluated light-weight, large area optics fabrication capabilities.
- Develop focal plane array, read out electronics, data processing algorithms.

	FY 2005	FY 2006	FY 2007
High Frequency Active Auroral Research Project (HAARP)	15.006	0.000	0.000

(U) The High Frequency Active Auroral Research Project (HAARP) developed new experimental research capabilities and conducted research programs to exploit emerging ionosphere and radio science technologies related to advanced defense applications. The FY 1990 Appropriation Act provided funds for the creation of HAARP, jointly managed by the Air Force Research Laboratory and the Office of Naval Research to exploit emerging ionosphere and high power radio technology for new military systems applications. Key to the current effort was the expansion of the experimental research facility that includes a 3.6 MW high-frequency transmitter and a variety of diagnostic instruments, to conduct investigations to characterize the physical processes that can be initiated and controlled in the ionosphere and space, via interactions with high power radio waves. Among these were: (1) the generation of extremely low frequency/very low frequency radio waves for submarine and other subsurface communication, and the reduction of charged particle populations in the radiation belts to ensure safe spacecraft systems operations; (2) the control of electron density gradients and the refractive properties in selected regions of the ionosphere to create radio wave propagation channels; and (3)

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the generation of optical and infrared emissions in space to calibrate space sensors. To date, the facility has been developed to include a suite of optical and radio diagnostics and an advanced, modern, high frequency transmitting array that has a radiated power of 960 kW, about one-third of the 3.6MW called for in the original concept and plan. The current high frequency transmitting array has proven to be extremely reliable and flexible, and has shown the feasibility of the overall concept. However, results to date have indicated that the advanced applications-related research activities and new military system concept demonstrations envisioned under the program require that the high frequency transmitting capability at the site be increased from the present 960 kW level to the originally planned 3.6 MW level. A study completed by an Air Force/Navy Panel also pointed to additional high-value functions that can potentially be accomplished with the a 3.6 MW capability, in particular, the exploration and refinement of scientific principles that could lead to the development and deployment of a system to provide protection for space-based assets from emergent asymmetric threats. DARPA established an MOA with the Air Force and Navy for this program in November 2002. The HAARP technology is transitioning to the Air Force and Navy in FY 2006.

(U) Program Plans:
- Completed the HAARP high frequency transmitting array at the HAARP Research Station, Gakona, AK.
- Prepared the existing HAARP facility in preparation for ionospheric testing.
- Conducted advanced ionosphere and radio science research and analysis of applications including space-based asset protection and phenomena related to its implementation.

	FY 2005	FY 2006	FY 2007
Sleight of HAND (SOH)	5.390	7.482	6.636

(U) This program will leverage technologies developed under the HAARP program, also budgeted under this project. The effects of High Altitude Nuclear Detonations (HAND) are catastrophic to satellites. HAND-generated charged particles are trapped for very long periods of time, oscillating between the earth's north and south magnetic poles. This enhanced radiation environment would immediately degrade low earth orbiting (LEO) spacecraft capability and result in their destruction in a short period of time. The Sleight of HAND (SOH) program is a proof of concept demonstration of the technology and techniques to mitigate the HAND-enhanced trapped radiation. The goal of SOH is to accelerate the rate of decay of trapped radiation from the LEO environment by a factor of 10 over the natural rate of decay. In Phase 1, SOH will use a high

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power ground-based source of very low frequency (VLF) radiation propagating through the ionosphere to deflect the trapped radiation deep into the atmosphere. If the ground-based proof of concept shows VLF radiation remediation concepts are valid and cost-effective, a space-based demonstration that may lead to an operational capability will be pursued. If successful, follow-on programs to perform HAND produced radiation remediation will be pursued by the Air Force.

(U) Program Plans:
- Develop VLF propagation and radiation interaction/effects model.
- Construct and deploy an instrumented buoy to sense and report VLF signal strength and effects of VLF on trapped radiation.
- Utilize the HAARP facility to perform 1-hop experiments to anchor VLF propagation and interactions model.
- Perform 2-hop experiments to further enhance the fidelity of VLF prediction codes.
- Use results of ground-based SOH experiments to develop requirements for a space-based SOH demonstrator.
- Perform space-based SOH demonstration.

	FY 2005	FY 2006	FY 2007
Suborbital Space Launch Operations / Improving Suborbital Operations	4.800	5.600	0.000

(U) The Suborbital Space Launch Operations/Improving Suborbital Operations program will design and develop an unmanned, reusable suborbital launch vehicle whose near term goal is to perform short duration testing of space flight hardware and ultimately to provide a platform for tactical battlefield surveillance.

(U) Program Plans:
- Designed and tested a restartable propulsion system for ascent and descent.
- Developed payload concepts for battlefield surveillance and sensor insertion.
- Developed a preliminary system design for the launch vehicle.
- Conduct system requirements review and initiate detailed design.

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	FY 2005	FY 2006	FY 2007
Space Assembly and Manufacture	4.200	0.000	0.000

(U) The objective of the Space Assembly and Manufacture program was to examine and validate technical options for manufacturing and assembling large space structures outside the confines of the Earth's gravity. Manufacturing in the space environment would enable novel structures that otherwise would not survive the loads experienced during terrestrial launch as well as the production of extremely large structures that enable large optical systems providing resolution and accuracy that are not otherwise conceivable. The size of such structures is currently limited by volume constraints of launch vehicle fairings. Such structures are important to address both national security and energy issues.

(U) The Space Assembly and Manufacture program identified key technical challenges and development areas for conducting a demonstration mission. These included: resource utilization, robotic processing, enabling structures and materials, power management, and manufacturing processes that can take advantage of the space environment. The program examined the feasibility of a number of manufacturing processes, including vacuum deposition, extrusion, nanotube utilization, and surface finishing.

(U) Program Plans:
- Identified key technical challenges and defined a demonstration mission to resolve critical issues for space manufacture.
- Complete final report.

	FY 2005	FY 2006	FY 2007
Electro-Dynamic Tethers	2.800	0.000	0.000

(U) The Electro-Dynamic (ED) Tethers program explored novel military space applications of tether-like structures. These included high-voltage electro-static designs that rapidly remediate high energy radiation particles produced by a High Altitude Nuclear Detonation (HAND). ED tethers also had the potential to provide novel propulsion and power generation by alternating the direction of the electric current flow along its

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length in the presence of the magnetic field and plasmasphere. This feature might enable the creation of a transformational military space propulsion and energy source—without the use of consumables—when an ED tether is attached to a satellite.

(U) Program Plans:
- Completed analytical analysis for tether HAND remediation, propulsion and power generation performance expectation.
- Developed candidate ES tether system design.
- Ground tested key high-voltage electro-dynamic tether components.

	FY 2005	FY 2006	FY 2007
Micro Electric Space Propulsion	3.800	3.857	4.689

(U) The Micro Electric Space Propulsion program (MEP) will demonstrate flexible, light-weight, high-efficiency, scalable micro-propulsion systems to enable a new generation of fast, long-lived, highly flexible, and highly maneuverable 1-100 kg-class satellites/spacecraft. In particular, the goals of the program are to demonstrate a thruster system capable of: (1) varying its specific impulse in real time across a range from 500 seconds to 10,000 seconds utilizing a single propellant, (2) operating with electrical thrust efficiencies in excess of 90% over significant portions of this range, (3) demonstrating a thruster specific mass less than 0.3 g/watt, and (4) demonstrating a propulsion system capable of delivering total mission delta-Vs for a 100 kg satellite in excess of 10 km/s. The MEP technology is planned for transition to the Air Force at the conclusion of Phase I, which is anticipated to be completed in FY 2007.

(U) Program Plans:
- Demonstrate proof-of-principle 1 watt thruster system capable of operating 50% efficiency at 2500 seconds and 7000 seconds specific impulse.
- Design of 2-D thruster array.
- Develop and demonstrate required Microelectromechanical Systems (MEMS) fabrication process, including development of high-aspect ratio machining and conformal surface modification techniques.
- Develop robust system design capable of tolerating single emitter failure.

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- Initiate propellant selection and optimization.
- Demonstrate thruster / propellant material compatibility.
- Demonstrate thruster operation.

	FY 2005	FY 2006	FY 2007
RAD Hard by Design	10.250	10.000	6.000

(U) This program, formerly titled Radiation Resistant Mixed Signal Electronics, will develop, characterize, and demonstrate microelectronic design technologies to enable fabrication of radiation hardened electronic components using leading-edge, commercial fabrication facilities. The current mainstream approach for fabricating radiation-hardened electronics depends on specialized process technologies and dedicated foundries that serve this military market niche. While commercial semiconductor fabrication is not explicitly radiation hardened, recent trends in deeply scaled fabrication such as very thin oxides, trench isolation, and multiple levels of metal are resulting in semiconductor devices that are inherently more tolerant of radiation than older generations. This program will pursue development design-based technologies that couple into pure commercial fabrication technologies to attain radiation hardened electronics equivalent to those from the dedicated foundries. The design technology developed under the Radiation Hardening by Design Program is planned for transition to the Air Force and to the Defense Threat Reduction Agency (DTRA) at the end of Phase 2 which is anticipated to be completed by FY 2007. Specific design libraries for hardened circuits will transition through the defense electronics design industry, which are being supported largely by DTRA and the Air Force.

(U) Program Plans:

- Prove that a pure design-based approach will be capable of attaining radiation hardened electronic devices with less than one generation penalty in terms of device area, speed, and power.
- Create design libraries needed for implementing integrated circuits.
- Demonstrate the ability to design and fabricate a fully hardened complex circuit using developed design-based methodology.

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	FY 2005	FY 2006	FY 2007
Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP)	6.600	7.000	8.000

(U) The Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) program will develop the advanced technologies, capabilities and space environment characterization required to demonstrate a suite of advanced lightweight microsatellite technologies integrated into high performance microsatellites across the continuum from low earth orbit (LEO) to deep space Super geo-synchronous orbit (GEO) environment. The program will integrate a variety of advanced technologies, which have not been previously flight-tested, and may include: lightweight optical space surveillance/situational awareness sensors, lightweight power, chemical and electric propulsion systems, advanced lightweight structures, advanced miniature RF technology including micro crosslink and use of Commercial Off the Shelf (COTS) approaches, active RF sensor technology, COTS processor and software environment, miniature navigation technologies, and autonomous operations. The developed capabilities may include high thrust, high efficiency solar thermal propulsion systems that can enable responsive orbit transfer as well as provide radiation resistant high density electrical power; ultra-stable payload isolation and pointing systems; and components to enable advanced miniature communication systems. The program will also consider affordable, responsive fabrication and integration approaches and the possibility of networking microsatellites/modules to create a flexible architecture of assets responsive to multiple missions and threats. If successful, MiDSTEP will demonstrate these technologies in space through Microsatellite Technology Experiments (MiTEx) and will support a variety of potential microsatellite projects.

(U) Program Plans:
- Conduct system design trades of appropriate technologies.
- Perform mission utility assessments and feasibility studies and develop concepts of operation.
- Design and develop microsatellite system concepts and integrate selected technologies.
- Perform component and subsystem ground tests, fabricate and flight test microsatellite system.

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	FY 2005	FY 2006	FY 2007
System F6	0.000	9.235	12.224

(U) The goal of System F6 program is to demonstrate a space system composed of a heterogeneous network of formation flying or loosely connected modules that will, working together, provide at least the same effective mission capability of a large monolithic satellite. Current large space systems used for national security purposes are constrained due to their monolithic architecture. They can be launched only on a small number of large launch vehicles, cannot readily be upgraded and/or reconfigured with new hardware on-orbit, and are risk-intensive, since the unforgiving launch and space environments can result in a total loss of investment with one mistake. Decomposition of a monolithic spacecraft into a fractionated space system offers the potential for reduced risk, greater flexibility (e.g. simplified on-orbit servicing, reconfigurability to meet changing mission needs), payload isolation, faster deployment of initial capability, and potential for improved survivability. This program will develop, design, and test new space system architectures and technologies required to successfully decompose a spacecraft into fundamental elements. Such architectures include, but are not limited to, ultra-secure intra-system wireless data communications, wireless power systems, electromagnetic formation flying systems, remote attitude determination systems, structure-less optical and RF arrays, and distributed spacecraft computing systems.

(U) Program Plans:

- Conduct system design trades of appropriate technologies and system architectures.
- Perform mission utility and econometric-based value assessments and feasibility studies and develop concepts of operations.
- Design and develop fractionated system concepts and integrate selected technologies.
- Perform component and subsystem ground tests.
- Fabricate and space test a microsatellite-scaled fractionated space system.

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	FY 2005	FY 2006	FY 2007
Front-end Robotics Enabling Near-term Demonstration (FREND)	0.000	9.100	13.445

(U) The goal of the Front-end Robotics Enabling Near-term Demonstration (FREND), formerly Spacecraft for the Universal Modification of Orbits (SUMO), program is to design, develop, demonstrate and fly technologies to increase survivability and operational effectiveness of commercial and military spacecraft. Currently, spacecraft parameters identify the state-of-health of vehicles leading to predetermined end-of-life criterion. FREND will enable continued safe operations and service life extension to these spacecraft. FREND combines detailed stereo photogrammetric imaging with robotic multi-degree-of-freedom manipulators to autonomously grapple space objects without custom interfaces. FREND offers the potential for spacecraft salvage, repair, rescue, reposition, and debris removal to extend service life or provide a safe and calculated de-orbit. Specific objectives of the FREND program include: development and demonstration of an autonomous rendezvous and grapple front end system; an effective, low total ownership cost design for the FREND system; and specific mission capabilities for geo-synchronous orbits (GEO). The anticipated transition partner is USAF Space Command.

(U) Program Plans:

- Design fabrication and ground testing of the sensing and robotic payload using flight hardware.
- Complete risk reduction lab test.
- Develop control algorithms for autonomous grapple and contingency operations.
- Procure and fabricate flight hardware for integration and testing.
- Conduct robotic payload ground test.
- Test control schemes in 1G environment.
- Conduct hardware-in-the loop testing in proximity operations test facility.
- Work with mission partner for full system integration and mission.

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	FY 2005	FY 2006	FY 2007
X-ray Navigation and Autonomous Position Verification (XNAV)	2.834	5.200	8.550

(U) The X-ray Navigation and Autonomous Position Verification (XNAV) program is expanding a technology thrust from the MiDSTEP program. It is an Advanced Technology Demonstration (ATD) involving the use of periodic x-ray celestial sources to determine the three-dimensional position, attitude and time of orbiting spacecraft. XNAV will develop, explore, and demonstrate the concept of operations (CONOPs) of a spacecraft equipped with an x-ray imager and photon counter to determine the feasibility and accuracy of x-ray pulsar sources for autonomous position, attitude and time determination in low earth orbit (LEO) for DoD navigation and communication satellites. The objective of the program is to develop a space qualified payload consisting of a gimbaled x-ray imager and photon counter that can be integrated and flown as an experiment aboard the International Space Station (ISS) Express Pallet, a NASA developed platform for space based experiments in support of DoD and NASA missions. The anticipated transition partner is USAF Space Command.

(U) Program Plans:

- Determine x-ray detector sensitivity, response time, signal-to-noise properties and timing electronics.
- Demonstrate expected navigation performance via detailed simulation.
- Successfully catalogue properties of rotation powered pulsar sources for navigation.
- Determine proper orientation of payload on ISS Express Pallet for optimum navigation performance.
- Develop preliminary x-ray detector system designs developed for the ISS Express Pallet.
- Select single x-ray detector design for development.
- Manufacture x-ray detector payload for ISS Express Pallet.
- Determine space qualifying payload.
- Conduct flight demonstration.
- Evaluate navigation performance.

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	FY 2005	FY 2006	FY 2007
Joint NASA/DoD Development	8.500	0.000	0.000

(U) The Joint NASA/DoD Development program coordinated related technology efforts between NASA and DARPA to ensure that both organizations derived the most benefit from each other's investments. NASA has initiated a program titled, Project Constellation, to fulfill the Vision for Space Exploration for missions to the lunar surface and beyond. This includes both robotic and crewed elements. NASA has identified the need for an in-space servicing to support this vision. The robotic autonomous proximity operations docking, fuel transfer, and in-space upgrade technologies under development in the Orbital Express (OE) program are directly applicable to the various aspects of Project Constellation. This program enabled DARPA and NASA to jointly investigate optimum operational concepts for mixed robotic and crewed operations.

(U) Program Plans:
- Designed fuel transfer system for bi-propellant cryogenic fuel transfer system.
- Developed CONOPS for manned- robotics collaboration in-space.
- Designed a robust proximity operations sensor suite based.

	FY 2005	FY 2006	FY 2007
Fast Access Spacecraft Testbed (FAST)	0.000	0.000	4.300

(U) The goal of the Fast Access Spacecraft Testbed (FAST) program is to demonstrate a suite of critical technologies required to perform rapid orbital repositioning in the geosynchronous belt. A high-efficiency, high-power (50-80 kW) fast-transfer roaming satellite would permit on-demand access to any point on the geosynchronous ring or within the high-altitude, supersynchronous "graveyard" (where derelict systems are regularly repositioned in order to free up orbital slots within the ring), greatly improving our space situational awareness capabilities. The FAST demonstrator satellite, while possessing high power, would be revolutionary in its small size. At just 500 kilograms, the FAST spacecraft would carry a novel solar power collection and distribution system, composed of large-aperture (5-10 m diameter) concentrating mirrors, high-efficiency

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solar photovoltaics, and ultralightweight, deployable radiators, achieving specific power (watts/kilogram) levels an order of magnitude better than today's state of the art.

(U) Program Plans:
- Conduct system design trades and investigate utility of applicable power and propulsion technologies.
- Perform preliminary design and technology selection.
- Perform detailed design and development of the FAST spacecraft, integrating selected technologies.
- Fabricate, qualify, and launch the FAST spacecraft to a low earth orbit to demonstrate proof-of-concept.

	FY 2005	FY 2006	FY 2007
Tiny, Independent, Coordinating Spacecraft (TICS)	0.000	0.000	4.800

(U) The Tiny, Independent, Coordinating Spacecraft (TICS) program is intended to leapfrog the microsatellite revolution, not simply through downsizing but through the addition of advanced robotics technologies to allow satellites to reconfigure on demand, many times over during the course of a mission. TICS will develop key technologies to permit the delivery of small, difficult-to-detect nanosatellites (1-10 kg) into any common operational orbit, from low earth orbit (LEO) to geosynchronous orbit (GEO), with little or no advance warning. TICS could be hosted aboard "mothership" platforms in LEO or GEO, or could be delivered directly via ultra-light launch platforms. Such systems could perform rapid-response reconnaissance on any spacecraft, with times to mission orbit measured in just hours. Such systems would be composed of modular, dockable subassemblies that could autonomously modify their morphologies to become apertures, free-flying formations, crawlers, or booms, as dictated by mission need. A TICS aggregate will be capable of assembling, disassembling, dispersing, and subsequently re-assembling, several times over. Enabling technologies include high-efficiency, miniaturized radar and active/passive optical sensors, multi-functional structures, software for advanced autonomous behavior (to include the ability to rendezvous, dock, undock, and formation-fly in multiple configurations), electric or chemical microthrusters, high energy density storage systems (including supercapacitors and advanced batteries), high efficiency energy conversion, and robust end effectors.

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(U) Program Plans:
- Conduct system design trades and provide "proof-of-concept" for a strawman TICS architecture.
- Conduct preliminary design, analysis, and key technology demonstrations.
- Perform detailed design and development of a TICS nanosatellite, integrating selected technologies and demonstrating aggregate behavior in a simulated space environment.
- Fabricate, qualify, and launch 5-10 TICS nanosatellites into low earth orbit, demonstrating multiple morphologies and missions.

(U) **Program Change Summary:** *(In Millions)*	**FY 2005**	**FY 2006**	**FY 2007**
Previous President's Budget	222.880	223.811	264.291
Current Budget	217.004	216.357	254.913
Total Adjustments	-5.876	-7.454	-9.378
Congressional program reduction	-0.171	-13.054	
Congressional increases	0.000	5.600	
Reprogrammings	0.000		
SBIR/STTR transfer	-5.705		

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(U) Change Summary Explanation:

FY 2005	Decrease reflects DOE transfer as directed by P.L. 108-447 and the SBIR/STTR transfer.
FY 2006	The decrease reflects the $10M congressional cut to Space Assembly and Manufacture, undistributed reductions for Section 8125 and the 1% reduction for Section 3801: Government-wide rescission. These were offset by a congressional add to Improved Suborbital Operations.
FY 2007	Decrease reflects cancellation of the Space Assembly and Manufacture program and minor shifts in program pricing and phasing.

(U) Other Program Funding Summary Cost:

Orbital Express Space Operations Architecture	FY 2005	FY 2006	FY 2007
Joint NASA/DoD Development	4.000	0.000	0.000

Falcon	FY 2005	FY 2006	FY 2007
PE 0604855, Air Force SPC	30.362	23.354	16.000
PE 0604856, Air Force SPC	14.464	23.000	26.500
NASA	3.560	0.000	0.000

Deep View	FY 2005	FY 2006	FY 2007
PE 0305910F, Air Force SPC	13.960	8.840	8.720