RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2005	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, R-1 # 33				
COST (In Millions)	FY 2004	FY2005	FY2006	FY2007	FY 2008	FY 2009	FY 2010	FY 2011
Total Program Element (PE) Cost	0.000	222.880	223.811	264.291	309.256	327.428	348.678	350.678
Space Programs and Technology SPC-01	0.000	222.880	223.811	264.291	309.256	327.428	348.678	350.678

(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. This program element was created in accordance with congressional intent in the FY 2005 DoD appropriations bill. Prior year funding was budgeted in PE 0603285E, Project ASP-02 and is noted as a memo entry within each program.

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(U) Program Accomplishments/Planned Programs:

	FY 2004	FY 2005	FY 2006	FY 2007
Orbital Express Space Operations Architecture	(44.418)	46.599	38.750	15.550

(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. In addition, a servicing satellite can support deployment and operations of micro-satellites for missions such as space asset protection and sparse aperture formation flying, or deploy nano-satellites for inspection to provide data to support satellite repair. 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 on the Hubble Space Telescope robotic servicing mission and to enable 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.
- Develop conceptual designs for nano-satellite servicing assistants.
- Perform utility assessments of on-orbit servicing in conjunction with operational customers and plan for technology transition.

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	FY 2004	FY 2005	FY 2006	FY 2007
Space Surveillance Telescope	(10.621)	18.673	18.592	12.842

(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 and novel optics design to build a telescope with a large aperture that provides detection sensitivity with a low-aberration wide field-of-view to provide rapid wide-area search coverage. 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 contributing sensor to the Air Force Space Surveillance Network. An MOA is being established with Air Force Space Command for transition the conclusion of Phase II, that is anticipated to be completed by FY 2009.

(U) Program Plans:
- Begin optics fabrication.
- Complete full mosaic tile fabrication.
- Begin wide-field camera integration.
- Begin processing and control software development.
- Begin telescope integration.
- Begin site preparation.

	FY 2004	FY 2005	FY 2006	FY 2007
Innovative Space-Based Radar Antenna Technology (ISAT)	(41.208)	46.000	45.000	43.000

(U) The Innovative Space-Based Radar Antenna Technology (ISAT) effort will develop radically new enabling technologies and design methods for extremely large space-based RF antenna technologies necessary for tactical-grade ground moving target indicator (GMTI) radar. Up to 300m 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. An antenna of this size

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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). ISAT technology also enables the detecting and tracking of all airborne targets using a constellation of 12 to 14 satellites in a high LEO orbit. The ISAT program will retire the risk associated with two major technical obstacles: 1) the reliable and controllable deployment of a ~300m long 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.

	FY 2004	FY 2005	FY 2006	FY 2007
Novel Satellite Communications	(0.000)	4.900	8.500	16.000

(U) The aim of the Novel Satellite Communications (NSC) program (formally known as Microsatellite Tactical Communications Network (MTCN)) is the development of an advanced, affordable, multi-user satellite communications (SATCOM) system using a medium earth orbit

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(MEO) constellation that allows ground-based users with the Joint Tactical Radio System (JTRS) 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 novel spacecraft design, advanced low-weight, highly compactable antennas, and novel signal processing and coding techniques.

(U) Program plans:
- Develop novel NSC system and spacecraft designs.
- Determine feasibility of novel signal processing concepts to enable robust communications.
- Carry out proof-of-concept demonstrations.

	FY 2004	FY 2005	FY 2006	FY 2007
Deep View	(9.520)	14.250	10.250	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.

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- Integrate into a low-power configuration in FY 2007, providing LEO-only capability.
- Demonstrate LEO-GEO imaging capability using a full set of gyro-twistrons.

	FY 2004	FY 2005	FY 2006	FY 2007
Responsive Access, Small Cargo, Affordable Launch (RASCAL)	(31.802)	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 MPV and ERV development portions of the program will not continue into Phase III. MIPCC testing and experiments will be conducted to demonstrate the utility of the propulsion augmentation technology.

(U) Program Plans:

- Developed Contractor Life Cycle Cost Model (CLCC).
- Selected preferred system concept(s).
- 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.
- Continue prototype Mass Injection Pre-Compressor Cooling (MIPCC) manifold – engine testing.

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	FY 2004	FY 2005	FY 2006	FY 2007
Tactically Responsive Satellites (TRS)	(5.016)	3.800	0.000	0.000

(U) The TRS program will develop 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 may play a role in under 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 will be transitioned to the newly formed Air Force Tactical Satellite (TACSAT) program at the end of FY 2005.

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

	FY 2004	FY 2005	FY 2006	FY 2007
Falcon	(17.500)	12.500	25.000	50.000

(U) The Falcon (formerly HyperSoar) program objectives are to develop and demonstrate hypersonic technologies that will enable the capability to execute 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 an 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

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implement this flight test program in an affordable manner, 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 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 NASA for this program 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:

- Preliminary design for HTV-1 technology flight demonstration vehicle completed.
- Complete SLV preliminary designs.
- Conduct early launch demonstrating responsive operations.
- Perform technology validation simulation and ground tests for hypersonic flight.
- Conduct SLV full scale motor 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.

	FY 2004	FY 2005	FY 2006	FY 2007
Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST)	(5.000)	7.000	2.000	2.000

(U) The Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST) program will develop technologies to enable low-cost, responsive spacecraft and capabilities, such as space situational awareness and blue force tracking. Key payload technologies will include light-weight optics,

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adaptive focal plane array sensors, and efficient space-qualified receivers and processors. The system will feature space-craft 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:
- Demonstrate light-weight, large area optics fabrication capability.
- Complete telescope design.
- Develop focal plane array, read out electronics, data processing hardware and algorithms.

	FY 2004	FY 2005	FY 2006	FY 2007
High Frequency Active Auroral Research Project (HAARP)	(15.944)	15.006	0.000	0.000

(U) The High Frequency Active Auroral Research Project (HAARP) will develop new experimental research capabilities and will conduct 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 is 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 are: (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) 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 indicate that 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 recent study completed by an Air Force/Navy Panel also points to additional high-value functions that can potentially be accomplished with the a 3.6 MW

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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 for this program in August 2002. The HAARP technology is planned for transition to the Air Force and Navy in FY 2006.

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

	FY 2004	FY 2005	FY 2006	FY 2007
Sleight of HAND (SOH)	0.000	5.810	10.482	15.450

(U) This program is an outgrowth of and 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 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 operational 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.

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- 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 2004	FY 2005	FY 2006	FY 2007
Suborbital Space Launch Operations / Improving Suborbital Operations	(1.500)	4.800	0.000	0.000

(U) The goal of the Suborbital Space Launch Operations/Improving Suborbital Operations program is to develop and demonstrate a piloted, reusable suborbital launch vehicle initially to perform short duration testing of space flight hardware, and ultimately to provide a platform for tactical battlefield surveillance.

(U) Program Plans:
- Design and test a restartable propulsion system for ascent and descent.
- Develop payload concepts for battlefield surveillance and sensor insertion.
- Develop a preliminary system design for the launch vehicle.

	FY 2004	FY 2005	FY 2006	FY 2007
Space Assembly and Manufacture	(4.200)	6.792	10.000	15.000

(U) The goal of the Space Assembly and Manufacture program is 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 will enable novel structures that could not survive the loads experienced during terrestrial launch. Extremely large structures enable resolution and accuracy from optical and radar systems that are not otherwise conceivable. Such structures are important to antennas, optics, solar collectors and other technologies to address both national security and energy issues. The Space Assembly and Manufacture program will comprise resource utilization, robotic processing, enabling structures, micro-satellite sensors, propellants and power generation. Manufacturing processes, such as vacuum deposition, extrusion,

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nanotube fabrication, etc., that can take advantage of the space environment will be included. Mass and complexity minimization of key components will drive the design of the system.

(U) The DARPA Space Robotics program will develop technologies for, and demonstrate the utility of, multi-jointed electromechanical arms for a variety of space servicing tasks. Traditional approaches to space vehicle servicing and docking require custom fittings and docking aids. One focus of the Space Robotics program will be to demonstrate an automated approach to proximity operations and grappling that do not require modifications to the spacecraft design. The program will first demonstrate the ability to locate, grapple, and assist a spacecraft in a ground based demonstration. Missions for a robotic space tug include repositioning, retirement maneuvers, and rescue of stranded spacecraft. Ultimately, this versatile technology will also be useful for repair of spacecraft anomalies, and for robotic assembly of large space structures and complex space systems that are launched into orbit in separate small modules that must then be assembled on orbit. The technology will also be useful for civil and commercial spacecraft operations.

(U) Program Plans:

- Identify key technical challenges and define a demonstration mission to resolve critical issues for space manufacture.
- Develop microsatellite and other sensor platforms that can determine chemical composition and location of resources on non-terrestrial objects.
- Design, fabricate and test miniaturized robotics capable of remotely processing materials and building rudimentary structures.
- Perform utility assessments of space manufacture in conjunction with operational customers and plan for technology transition.
- Create realistic docking models and solar lighting conditions in a proximity operations simulation facility.
- Conduct demonstration in proximity operations simulation facility of dockings with a variety of realistic spacecraft geometries, lighting conditions, and relative motion.
- Develop a preliminary design of the demonstration space vehicle.

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	FY 2004	FY 2005	FY 2006	FY 2007
Electro-Dynamic Tethers	(0.000)	2.800	0.000	0.000

(U) The Electro-Dynamic (ED) Tethers program will demonstrate novel military space applications of tether-like structures. These include high-voltage electro-static designs that rapidly remediate high energy radiation particles produced by a High Altitude Nuclear Detonation (HAND). ED tethers also provide novel propulsion and power generation by alternating the direction of the electric current flow along its length in the presence of the magnetic field and plasmasphere. This will enable the potential for a transformational military space propulsion and energy source—without the use of consumables—when an ED tether is attached to a satellite. Although the concept of an ED tether is feasible, several technology advances are required to make it practical. In particular, extremely long ED tethers are required (~10 km) to provide sufficient Lorentz force for orbital boost and/or inclination change, impulsive energy generation due to a drop in altitude, as well as timely HAND remediation. Other issues to be addressed include: multi-kilometer structure dynamic stability and control during deployment, retraction and operation; electro-dynamic coupling efficiency to the plasmasphere without the use of consumables; and electrostatic influence on highly energetic, manmade charged radiation particles.

(U) Program Plans:

- Completed analytical analysis for tether HAND remediation, propulsion and power generation performance expectation.
- Develop candidate ES tether system design.
- Ground test key high-voltage electro-dynamic tether components.
- Flight qualify tether space flight experiments payload for placement on a small, high-powered satellite bus.
- Space demo to facilitate transition as part of the Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP).

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	FY 2004	FY 2005	FY 2006	FY 2007
Micro Electric Space Propulsion	(0.000)	3.800	2.762	0.659

(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 sec. to 10,000 sec. 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 s and 7000 s 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.
- Initiate propellant selection and optimization.
- Demonstrate thruster / propellant material compatibility.
- Demonstrate thruster operation.

	FY 2004	FY 2005	FY 2006	FY 2007
RAD Hard by Design	(8.946)	10.250	4.500	0.000

(U) This program, formerly titled Radiation Resistant Mixed Signal Electronics, will develop, characterize, and demonstrate the mixed-signal Rad by Design solution with assured access to commercial foundry for low volume applications. This program will develop and demonstrate

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microelectronic design technologies to enable fabrication of radiation hardened electronic components through 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 niche military market. 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.

	FY 2004	FY 2005	FY 2006	FY 2007
Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP)	(0.000)	6.600	7.000	11.000

(U) The Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) program, expanding on a thrust area initiated under the Space Assembly and Manufacture and RAD Hard by Design programs, also budgeted under this project, 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

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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 microsatellie system concepts and integrate selected technologies.
- Perform component and subsystem ground tests, fabricate and flight test microsatellite system.

	FY 2004	FY 2005	FY 2006	FY 2007
Space Awareness (SPAWN)	(0.000)	0.000	14.000	24.000

(U) The goal of the Space Awareness (SPAWN) program is to provide near field space situational awareness (SSA) around U.S. satellites and offboard satellite anomaly resolution. Assuring the ability to operate in space is essential for the conduct of U.S. military operations and assured operations cannot be guaranteed without situational awareness. An offboard capability to diagnose satellite anomalies will reduce the time required to restore satellites to fully mission capable status. The SPAWN program will determine the capabilities needed for performing near-field SSA and satellite anomaly resolution, develop new technologies or modify existing systems to provide situational awareness and anomaly detection, and create an architecture that parses these capabilities between new and existing systems. SPAWN will leverage lightweight, space-qualified telescope technology developed under the ROAST program, and provide risk reduction for future Air Force systems.

(U) Program Plans:
- Design and develop architecture and CONOPS for SSA and offboard anomaly resolution.
- Develop conceptual designs for SPAWN systems and modifications, identify enabling technologies, and parameterize capabilities.

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– Develop, design, and fabricate, and test prototype technologies and techniques.

	FY 2004	FY 2005	FY 2006	FY 2007
System F6	(0.000)	0.000	9.135	17.000

(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, in unison, 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, and 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 2004	FY 2005	FY 2006	FY 2007
Spacecraft for the Unmanned Modification of Orbits (SUMO)	(0.000)	0.000	12.640	22.340

(U) The goal of the Spacecraft for the Universal Modification of Orbits (SUMO) program, an expansion of the robotics work initiated under the Space Assembly and Manufacture program, also budgeted under this project, is to design, develop and demonstrate 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. SUMO will enable continued safe operations, and service life extension to these spacecraft. SUMO combines detailed stereo photogrammetric imaging with robotic multi degree of freedom manipulators to autonomously grapple space objects without custom interfaces. SUMO 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 SUMO program include: development and demonstration of an autonomous rendezvous and grapple front end system; an effective, low total ownership cost design for the SUMO system; and specific mission capabilities for low earth orbit (LEO) and geo-synchronous orbit (GEO).

(U) Program Plans:

- Design fabrication and ground testing of the sensing and robotic payload using non-flight hardware.
- Complete risk reduction lab demonstration.
- Develop control algorithms for autonomous grapple and contingency operations.
- Fabrication and procurement of flight hardware for integration and testing.
- Robotic payload ground test.
- Payload integration.
- Test control schemes in “virtual space” environment.
- Hardware-in-the-loop testing in proximity operations test facility.

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	FY 2004	FY 2005	FY 2006	FY 2007
X-ray Navigation and Autonomous Position Verification (XNAV)	(0.000)	2.300	5.200	9.200

(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. The XNAV ATD 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.
- Space qualify payload.
- Conduct flight demonstration.
- Evaluate navigation performance.

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	FY 2004	FY 2005	FY 2006	FY 2007
Joint NASA/DoD Development	0.000	8.500	0.000	0.000

(U) The Joint NASA/DoD Development program will coordinate related technology efforts between NASA and DARPA to ensure that both organizations derive 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 will build on insights gained in the design and development of Orbital Express to begin the design of robust in-space servicing elements and investigate optimum CONOPS for mixed robotic and crewed operations.

(U) Program Plans:

- Design fuel transfer system for bi-propellant cryogenic fuel transfer system.
- Develop CONOPS for manned- robotics collaboration in-space.
- Design a robust proximity operations sensor suite based.

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(U) Program Change Summary: *(In Millions)*

	FY 2005	FY2006	FY2007
Previous President's Budget	249.220	233.606	261.769
Current Budget	222.880	223.811	264.291
Total Adjustments	-26.340	-9.795	2.522

Please note that this program element was established in accordance with congressional intent in FY 2005. FY 2004 and prior was funded under PE 0603285E. The *Previous President's Budget* amounts reflect project ASP-02.

Congressional program reduction	-39.640
Congressional increases	13.300
Reprogrammings	0.000
SBIR/STTR transfer	0.000

(U) Change Summary Explanation:

FY 2005	Decrease reflects congressional reductions to Orbital Express, Rascal, CAV, and undistributed reduction offset by congressional adds for Improving Sub-Orbital operations and Joint NASA/DoD Development.
FY 2006	Decrease reflects project rephrasing following discontinuation of the current RASCAL program.
FY 2007	Increase reflects minor project repricing.

(U) Other Program Funding Summary Cost:

	FY 2004	FY 2005	FY 2006	FY 2007
Orbital Express Space Operations Architecture				
NASA	4.000	0.000	0.000	0.000

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High Frequency Active Auroral Research Project (HAARP)	FY 2004	FY 2005	FY 2006	FY 2007
PE 0601153N, Navy	15.000	16.000	0.000	0.000
PE 0602601F, Air Force	10.000	10.000	10.000	0.000

Falcon	FY 2004	FY 2005	FY 2006	FY 2007
PE 0604855, Air Force SPC	22.344	30.362	23.354	16.000
PE 0604856, Air Force SPC	12.220	16.610	23.000	26.500
NASA	8.000	2.000	0.000	0.000