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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE February 2008	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E, Project SPC-01				
COST (In Millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	222.300	216.419	287.009	211.510	235.331	250.032	254.221
Space Programs and Technology SPC-01	222.300	216.419	287.009	211.510	235.331	250.032	254.221

(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. The keys to a secure space environment are situational awareness to detect and characterize potential attacks, a proliferation of assets to provide robustness against attack, 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.

(U) 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 2007	FY 2008	FY 2009
Orbital Express Space Operations Architecture	34.711	0.000	0.000

(U) The goal of the Orbital Express Space Operations Architecture program was 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 would 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 provide performance improvements and dramatically reduce the time to deploy new technology on-orbit. The Orbital Express advanced technology demonstration designed, developed and tested 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, was tied together by non-proprietary satellite servicing interfaces (mechanical, electrical, etc.) facilitating the development of an industry wide on-orbit servicing infrastructure. Orbital Express successfully launched in March 2007 as part on the Air Force Space Test Program’s STP-1 mission. The demonstration program met all mission success criteria and was completed in July 2007.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed and validated software for autonomous mission planning, rendezvous, proximity operations and docking.
- Designed, fabricated, and tested on-orbit robotic satellite servicing, including fuel and electronics transfer, deployment of and operations with a micro-satellite.
- Performed utility assessments of on-orbit servicing in conjunction with operational customers.

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	FY 2007	FY 2008	FY 2009
Space Surveillance Telescope (SST)	19.771	12.833	7.000

(U) The Space Surveillance Telescope (SST) 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. A major goal of the SST program is to develop the technology for large curved focal plane array sensors 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 deep space for purposes such as asteroid detection and space defense missions. The Air Force will participate in the DARPA funded developmental testing of SST and then take over operation of SST as a sensor in the Air Force Space Surveillance Network. A Memorandum of Agreement (MOA) has been established with Air Force Space Command for transition in FY 2009.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed and fabricated major components of the 3.5m aperture telescope.
- Designed telescope enclosure.

FY 2008 Plans:

- Develop and fabricate a mosaic of curved focal plane arrays and construct the sensor subsystem.
- 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.
- Integrate telescope elements at contractor facility.

FY 2009 Plans:

- Integrate telescope elements on site.
- Validate end-to-end telescope performance and surveillance operations.

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	FY 2007	FY 2008	FY 2009
Novel Satellite Communications (NSC)	16.275	15.622	3.800

(U) The aim of the Novel Satellite Communications (NSC) program is the development of a 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 novel signal processing, communications and coding techniques. The NSC technology will transition to the Navy (SPAWAR) and Air Force (SMC) following the NSC demonstration in 2009.

(U) Program plans:

FY 2007 Accomplishments:

- Collected experimental SATCOM jamming data using Tracking and Data Relay Satellite System (TDRSS) and Commercial SATCOM satellites, and demonstrated that the NSC algorithms being developed worked on the data collected.
- Developed detailed hardware and software design of the NSC demonstration system.

FY 2008 Plans:

- Conduct additional experimental data collection and processing.
- Finalize design of the NSC demonstration system.
- Begin integration of the NSC System.
- Conduct performance testing of key demonstration subsystems.

FY 2009 Plans:

- Complete assembly of the NSC system.
- Conduct testing and proof of concept demonstrations.

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	FY 2007	FY 2008	FY 2009
Integrated Sensor is Structure (ISIS)	23.318	29.000	44.000

(U) The Integrated Sensor is Structure (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-plus months of autonomous, unmanned flight; hundreds of wideband in-theater covert communications links; responsive reconstitution of failed space assets; plus CONUS-based sensor analysis and operation. The ISIS technology is planned for transition to the Army’s PEO Air-to-Surface Missile Defense, Air Force Joint Warfighter Space and the Missile Defense Agency by FY 2011.

(U) Program Plans:

FY 2007 Accomplishments:

- Refined objective system concept designs enabling simultaneous AMTI and GMTI operation, one year logistics-free operation, 99% on-station availability, and high-bandwidth covert communications.
- Developed 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).

FY 2008 Plans:

- 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).
- Develop a preliminary design and fully-operational scaled flight system demonstrating complete system integration over an extended period.

FY 2009 Plans:

- Design and simulate new radar modes; tracking air and ground targets through the clutter notch; detection and response to rockets, artillery, and mortars; detection of dismounted enemy combatant; and “track-all-the-way” fire control.

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- Integrate and flight test a sub-scaled airship demonstrating launch and recovery operations, station-keeping and altitude control algorithms, and validate environmental data models.
- Design and simulate new radar modes; tracking air and ground targets through the clutter notch; detection and response to rockets, artillery, and mortars; detection of dismounted enemy combatant; and “track-all-the-way” fire control.
- Develop a critical design for a fully-operational scaled flight system demonstrating complete system integration over an extended period.

	FY 2007	FY 2008	FY 2009
Deep View	10.250	4.730	0.000

(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-synchronous 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 a joint MOA with the Air Force for this program in August 2004, and technologies developed under the Deep View program are transitioning in FY 2008.

(U) Program Plans:

FY 2007 Accomplishments:

- Developed W-band gyro-twystron transmitter tubes.
- Developed the technology for W-band power combining and frequency multiplexing, to obtain the required transmitter power over the required bandwidth for deep space imaging.
- Completed transmitter and radar system design, retaining the current Haystack X-band capability.

FY 2008 Plans:

- Demonstrate 4-tube gyro-twystron power combining to verify diplexer performance under near-operational conditions.

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- Complete development of advanced signal processing software required by the new broadband high power transmitter approach.

	FY 2007	FY 2008	FY 2009
Long View	9.430	13.809	18.989

(U) The Long View program will develop an inverse synthetic aperture laser radar (LADAR) that will enable the high-resolution imaging of geostationary satellites when coupled to a large aperture telescope. Specifically, the technologies being developed in the Long View program are an optical reference oscillator that is stable over the propagation time to a geostationary satellite (GEOSTAT) and back (about a quarter of a second) and autofocus algorithms that restore image quality that has been degraded due to atmospheric turbulence and optical reference oscillator instability over the imaging time (about 100 seconds). These two technologies are required in order to make inverse synthetic aperture LADAR systems feasible for objects in geostationary orbits. The Long View technology will transition to the Air Force in 2012.

(U) Program Plans:

FY 2007 Accomplishments:

- Designed and began assembling the stable optical reference oscillator.
- Simulated autofocus algorithms.
- Developed and tested autofocus algorithms.

FY 2008 Plans:

- Demonstrate that the stable optical reference oscillator meets stability requirements.
- Demonstrate that the autofocus algorithm is capable of eliminating the blurring due to atmospheric turbulence and stable optical reference oscillator instability over the imaging time.
- Commence design of the Long View demonstration system.
- Conduct measurement of atmospheric turbulence at sub-Hertz frequencies.

FY 2009 Plans:

- Complete design of Long View demonstration system.
- Integrate hardware with telescope.
- Complete measurements of atmospheric turbulence.

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- Fabricate the Long View demonstration system.
- Conduct high-resolution imaging of geostationary satellites.

	FY 2007	FY 2008	FY 2009
Falcon	51.500	25.000	25.000

(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 at 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. The HTV-2 program will demonstrate enabling hypersonic technologies for future operational systems through rocket-boosted hypersonic flights with sufficient cross-range and downrange performance to evaluate thermal protection systems, aerodynamic shapes, maneuverability, and long-range communication for hypersonic cruise and re-entry vehicle applications. The HTV-3X program will demonstrate key Hypersonic Cruise Vehicle technologies in a realistic flight environment by developing a re-usable hypersonic aircraft test bed capable of takeoff from runway under turbojet power, acceleration to Mach 6 speed under combined turbojet and scramjet propulsion, controlled deceleration, and runway landings. In order to implement this flight test program in an affordable manner, Falcon will develop a low-cost, responsive Small Launch Vehicle (SLV). 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 the HTV-2 program in May 2003 and with NASA in October 2004. Falcon capabilities are planned for transition to the Air Force.

(U) An MOA with the Air Force in FY 2007 established the HTV-3X Blackswift Test Bed program. Given the importance of this activity, the HTV-3X Blackswift Test Bed has been separately budgeted in FY 2008 and out in this Program Element.

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- (U) Program Plans:
- FY 2007 Accomplishments:
- Conducted a second demonstration SLV launch.
 - Manufactured an integrated second stage of an SLV.
 - Conducted long-duration hot firing tests for second stage VaPak engine.
 - Built a new horizontal test stand for more, and longer, second stage hot firings.
 - Conducted HTV-2 preliminary design review.
 - Conducted HTV-3X feasibility study.
 - Conducted wind tunnel testing of HTV-2 outer mold line and completed aero critical design review.
 - Completed HTV-2 aeroshell prototype parts fabrication and conducted leading-edge arc-jet test.
 - Initiated concept design of the HTV-3X technology flight demonstration vehicle.
- FY 2008 Plans:
- Conduct critical design review of HTV-2 demonstration system and initiate fabrication.
- FY 2009 Plans:
- Complete assembly, integration, and test (AI&T) of two HTV-2 vehicles.
 - Conduct flight testing of HTV-2 vehicles incorporating next generation hypersonic technologies.

	FY 2007	FY 2008	FY 2009
Blackswift Test Bed*	0.000	35.000	70.000

*Formerly Falcon HTV-3X.

(U) The Blackswift Test Bed program will develop an extended duration hypersonic test bed which will allow for the study of tactics for a hypersonic airplane that includes a runway take-off, Mach 6 cruise, and a runway landing. This test bed is an evolution of the reusable Hypersonic Cruise Vehicle developed under the Falcon program. Key technologies that will be demonstrated include efficient aerodynamic shaping for high lift to drag, lightweight and durable (reusable) high-temperature materials and thermal management techniques including active cooling, autonomous flight control, and turbine-based combined cycle propulsion. To accomplish this objective, the Blackswift program will leverage propulsion component technologies developed by the Air Force and DARPA. It is envisioned that flying this hypersonic aircraft test bed in a

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relevant, flight environment will permit the future development of enhanced-capability reusable high-speed vehicles for intelligence, surveillance, reconnaissance, strike or other national need missions. This program will transition to the Air Force following completion of flight-testing.

(U) Program Plans:

FY 2008 Plans:

- Conduct HTV-3X propulsion trade studies.
- Conduct HTV-3X conceptual design review.
- Conduct further second stage engine firing tests on the horizontal and vertical test stands to validate the VaPak system.

FY 2009 Plans:

- Develop Blackswift preliminary design, risk management plan, and technology and system maturation plan.
- Mature and ground test the scramjet flow path.
- Integrate the scramjet with the high-speed turbine engine.
- Complete a turbine-based combined-cycle propulsion ground demonstration.

	FY 2007	FY 2008	FY 2009
Sleight of HAND (SOH)	9.636	12.710	17.045

(U) The effects of High Altitude Nuclear Detonations (HAND) are catastrophic to satellites. HAND-generated charged particles are trapped for very long periods of time, possibly for years, 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 within a few weeks. The Sleight of HAND (SOH) program is a proof-of-concept demonstration of the technology and techniques to rapidly mitigate the HAND-enhanced trapped radiation within days of a HAND event, before LEO spacecraft capabilities are degraded. Other slower remediation methods, taking weeks versus days, would result in spacecraft degradation and would require asset replacement. The SOH effort will explore two alternative approaches to radiation mitigation: 1) using ground transmitted very low frequency (VLF) transmissions to interact with trapped particles and 2) using neutral gas release in space to generate plasma interactions producing ultra low frequency (ULF)/VLF energy to interact with trapped particles. Following laboratory proof-of-concept experiments and a risk reduction sounding rocket flight, a space-based demonstration will be pursued as a pathfinder for a future program in space remediation capability. Potential transition partners include the Navy and Air Force.

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- (U) Program Plans:
- FY 2007 Accomplishments:
- Developed VLF propagation and radiation interaction/effects model.
 - Constructed and deployed an instrumented buoy to sense and report VLF signal strength and effects of VLF on trapped radiation.
 - Utilized the HAARP facility to perform 1-hop experiments to anchor VLF propagation and interactions model.
 - Performed 2-hop experiments to further enhance the fidelity of VLF prediction codes.
 - Performed feasibility studies to determine potential performance of neutral gas release radiation mitigation strategy.
- FY 2008 Plans:
- Use results of ground-based SOH experiments to enhance requirements for a space-based SOH demonstrator.
 - Develop risk reduction sounding rocket experiment to validate neutral gas release and timing.
- FY 2009 Plans:
- Perform risk reduction sounding rocket flight, evaluate results, and incorporate into proposed demonstration.
 - Develop preliminary design for space-based SOH neutral gas release demonstration.

	FY 2007	FY 2008	FY 2009
RAD Hard by Design	5.000	4.220	4.705

(U) This program is developing, characterizing, and demonstrating 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 is pursuing development of design-based technologies that will enable 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 II, which is anticipated to be completed by FY 2009. 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.

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- (U) Program Plans:
- FY 2007 Accomplishments:
- Developed a Rad Hard by Design (RHBD) standard cell Application-Specific Integrated Circuit (ASIC) library in a commercial 90 nanometer (nm) complementary metal-oxide-semiconductor (CMOS) process.
 - Achieved specified Rad-hard performance metrics with only a “one technology node” penalty in terms of performance, area and power.
- FY 2008 Plans:
- Identify candidate system-on-a-chip integrated circuit (IC) to harden utilizing the RHBD standard cell libraries previously developed by this program.
 - Fabricate “intermediate” demonstration IC as preliminary to the complete RHBD version of the system on chip (SOC) above.
 - Begin exploration of 65 nm technology with respect to RHBD methods.
 - Begin exploration of silicon on insulator (SOI) technology with respect to RHBD methods.
- FY 2009 Plans:
- Fabricate and test “final” RHBD demo ICs chosen in FY 2008 (90 nm CMOS technology).
 - Complete investigation of RHBD efficacy in 65 nm CMOS technology.
 - Complete investigation of RHBD efficacy in SOI technology.

	FY 2007	FY 2008	FY 2009
Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP)	8.000	10.000	8.000

(U) The Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) 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 radio frequency (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, including the use of

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starfields for deep space navigation, and autonomous operations. The developed capabilities will 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. The program will also explore ultra-stable payload isolation and pointing systems and components to enable advanced miniature communication systems. In addition, the program will also consider affordable, responsive fabrication and integration approaches and the possibility of networking microsattellites/modules to create a flexible architecture of assets responsive to multiple missions and threats. If successful, MiDSTEP will demonstrate these technologies in space. The anticipated transition partner is Air Force Space Command.

(U) The Microsatellite Technology Experiment (MiTEx) technology demonstration investigated and demonstrated advanced high-payoff technologies from a variety of potential candidates, including: lightweight power and propulsion systems, avionics, structures, COTS components, advanced communications, and on-orbit software environments. MiTEx flight-tested a new, experimental upper stage, and demonstrated small COTS technologies to support a fast-paced, low-cost, lab-like, build-to-launch satellite approach in a shared industry/government environment.

(U) Program Plans:

FY 2007 Accomplishments:

- Completed MiTEx technology demonstration.

FY 2008 Plans:

- Conduct system design trades of appropriate technologies.
- Perform mission utility assessments and feasibility studies and develop concepts of operation.

FY 2009 Plans:

- Design and develop microsatellite system concepts and integrate selected technologies.
- Perform component and subsystem ground tests.

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	FY 2007	FY 2008	FY 2009
System F6	12.224	21.095	37.270

(U) The goal of the System F6 program is to demonstrate a radically new space system composed of a heterogeneous network of formation flying or loosely connected small satellite 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. The System F6 will partition the tasks performed by monolithic spacecraft (power, receivers, control modules, etc.) and assign each task to a dedicated small or micro satellite. This 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, distributed spacecraft computing systems, and reliable, robust, rapidly re-locatable ground systems. The anticipated transition partner is the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted system design trades of appropriate technologies and system architectures.
- Performed mission utility and econometric-based value assessments and feasibility studies and developed concepts of operations.

FY 2008 Plans:

- Design and develop fractionated system concepts and integrate selected technologies.
- Formulate econometric value-modeling methodologies to inform system engineering trade decisions.
- Conduct Hardware-In-the-Loop (HIL) demonstrations of successively greater capability simulating wireless network operating environment for fractionated satellite systems.
- Develop trajectories for launch, deployment and sustainment of cluster satellite systems.

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- Review feasibility of wireless power transfer approaches for inter and intra-satellite operations.
- FY 2009 Plans:
- Perform component and subsystem ground tests.
 - Conduct Hardware-In-the-Loop (HIL) demonstrations of successively greater capability simulating 1) wireless network operating environment for fractionated satellite systems, 2) orbit propagation with real world dynamics, 3) guidance, navigation and control schemes, 4) cluster flying algorithms, and 5) distributed resource management.
 - Refine system design to provide a detailed description of spacecraft and ground modules, subsystem-level allocation of mass, power and reliability, trade space definition for each component/technology, and risk analysis with mitigation schemes.

	FY 2007	FY 2008	FY 2009
Front-end Robotics Enabling Near-term Demonstration (FRIEND)	13.196	14.400	10.700

(U) The goal of the Front-end Robotics Enabling Near-term Demonstration (FRIEND) program is to develop, demonstrate and fly robotic manipulator technologies designed to allow interaction with geosynchronous orbit (GEO)-based military and commercial spacecraft, extending their service lives and permitting satellite repositioning or retirement. Existing GEO spacecraft are outfitted with sufficient propellant to provide for needed station keeping, repositioning, and retirement maneuvers, which in many cases defines their useful mission durations. Once this propellant is expended, the vehicle is retired and, in many cases replaced. FRIEND technologies can enable significant service extension to these spacecraft through re-boosting near end-of-life. FRIEND combines detailed stereo photogrammetric imaging with robotic multi-degree-of-freedom manipulators to autonomously grapple space objects not outfitted with custom interfaces. A FRIEND-based servicing spacecraft offers the potential for spacecraft salvage, repair, rescue, reposition, de-orbit and retirement, and debris removal. The anticipated transition partner is the Air Force.

- (U) Program Plans:
- FY 2007 Accomplishments:
- Designed, fabricated, and ground tested the rendezvous sensor and robotic payload elements.
 - Conducted risk reduction lab testing.
 - Developed control algorithms for autonomous grapple and contingency operations.

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FY 2008 Plans:

- Procure and fabricate flight hardware for integration and testing.
- Conduct robotic payload ground test.
- Test control schemes in 1G environment.

FY 2009 Plans:

- Conduct hardware-in-the loop testing in proximity operations test facility.
- Work with mission partner to develop demonstration mission.

	FY 2007	FY 2008	FY 2009
Fast Access Spacecraft Testbed (FAST)	4.300	7.000	12.000

(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. The ultimate goal of FAST is to demonstrate technology to enable a high-efficiency, high-power (50-80 kW), fast-transfer roaming satellite permitting on-demand access to any point on the geosynchronous ring or within the high-altitude, super synchronous “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 (20 kW or more), would be revolutionary in its small size. At just 500 kilograms, a FAST spacecraft would carry a novel solar power collection and distribution system, composed of large-aperture (5-10 m diameter) concentrating mirrors, high-efficiency solar photovoltaics, and ultra-lightweight, deployable radiators, achieving specific power (130 watts/kilogram at the power subsystem level) figures an order of magnitude better than today’s state of the art. The anticipated transition partner is the Air Force.

(U) Program Plans:

FY 2007 Accomplishments:

- Conducted system design trades and investigated utility of applicable power and propulsion technologies.

FY 2008 Plans:

- Perform preliminary design and technology selection.
- Perform detailed design, development, and ground testing of the FAST spacecraft high-power generation subsystem.

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FY 2009 Plans:

- Initiate design and development of the FAST demonstrator spacecraft.

	FY 2007	FY 2008	FY 2009
NanoPayload Delivery (NPD)	0.000	3.000	6.000

(U) The goal of the NanoPayload Delivery (NPD) program is to validate the technical feasibility of ultra-lightweight, rapid-response spacecraft delivery from land, sea, or air-based platforms. Such nanopayloads (1-10 kilograms) could be boosted to low earth orbit (200 km altitude) in a matter of hours following call-up. Multiple sorties are envisioned, enabling a number of small spacecraft to be placed in an orbit “box” and aggregated together to perform a mission. The NPD program will develop and test a lightweight rocket platform similar in size to existing small missile systems such as the High-Speed Anti-Radiation Missile (HARM), AIM-7, or AIM-120. Current technology does not permit such small systems to reach orbit, owing to disproportionately high drag and low thrust-to-weight rocket engines. NPD will leverage ongoing technology development efforts, which permit the fabrication of microscale pumps, thrust chambers, and valves. Such rocket engines, which are theoretically capable of thrust-to-weight ratios of 100:1 or greater, would allow for significant reductions in overall engine mass and permit nanosatellites to be placed in low orbits for several weeks to months. The delivery system would rely on one of several methods for launch, including: (1) a stock aircraft, such as the F-15E or F-16, (2) a truck-mounted erector, or (3) the deck of a small naval vessel. The goal for per-sortie cost is \$100,000. Fielding NPD will permit U.S. forces to rapidly emplace short-term capabilities in low orbit, when they are needed, without resorting to legacy domestic launch systems that are sized and costed for much larger payloads. NPD will also allow many non-traditional users (e.g. laboratories, operational commanders, and small commercial firms) the capability to “use space” by lowering the significant barrier to entry into space. NPD will allow a streamlined, inexpensive approach to launch, descope lengthy test and documentation requirements and demanding far fewer engineers, technicians, range personnel, and spacecraft operators per mission. Potential transition customers include the Air Force and Navy.

(U) Program Plans:

FY 2008 Plans:

- Survey existing aircraft-, land-, and sea-based missile platforms for compatibility with NPD mission constraints and requirements.
- Design, fabricate, and test an integrated micro chemical engine; including pumps, lines, valves, and thrust chamber; to validate performance models.

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FY 2009 Plans:

- Design, develop, and test arrays of micro engines for use as the first and upper stages of the NPD rocket platform.
- Integrate and test micro engine arrays on selected missile platforms.

	FY 2007	FY 2008	FY 2009
Space Situational Awareness & Counterspace Operations Response Environment	0.000	4.000	7.000

(U) The goal of the Space Situational Awareness (SSA) & Counterspace Operations Response Environment (SCORE) program is to develop and demonstrate an operational framework and responsive defense application to enhance the availability of vulnerable commercial space-based communications resources. SCORE will correlate a wide range of operational support and space system ground user data to rapidly identify threat activities, propose mitigating countermeasures, and verify the effectiveness of selected responses. Critical technologies include accessing disparate sources of relevant data, model-based situational awareness, and candidate response generation and evaluation. Particular emphasis will be placed on the ability to continuously adapt to changes in defended system components and usage patterns as well as validation of SCORE system integrity. The potential transition customer is the Air Force.

(U) Program Plans:

FY 2008 Plans:

- Develop initial system requirements and design.
- Develop adaptive model of defended systems and identify relevant sources of data.

FY 2009 Plans:

- Conduct system trades and validate critical components.
- Mature system parameters and operational procedures.

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	FY 2007	FY 2008	FY 2009
MEO Synthetic Aperture Radar (MEOSAR)	0.000	0.000	4.000

(U) Synthetic Aperture Radar (SAR) integration time is currently limited by the amount of ground vehicle motion encountered during the synthetic aperture collection time. For space radar systems, this has traditionally meant that SAR had to be accomplished at low earth orbit (LEO) trajectories where the collection time would be much shorter given the high speeds of a LEO satellite. Although the specifics depend heavily on geometric considerations, medium earth orbit (MEO) SAR imaging intervals can be a factor of approximately eight longer, compared to a LEO alternative. The longer integration times required at MEO can have a major impact on the quality of the otherwise equivalent SAR image due to the presence of internal motion within the image scene. To achieve equivalent quality imagery, the contribution of the moving targets within the image must be excised. The MEOSAR program will develop techniques to identify moving targets and extract them from the data prior to imaging to avoid the streaking caused by their motions. The program will develop reliable automated detection of moving targets within SAR imagery using a double thresholding process in interferometric phase and amplitude. This moving target detection technique can be readily reversed to excise the moving targets from the clutter (image) background. Temporal sub-array processing will demonstrate early detection and rejection of moving targets in sub-array images. The program will develop improved motion detection and removal algorithms, demonstrate their performance on simulated and airborne data, and develop an architectural concept for a MEOSAR system. This program will transition to the Air Force and STRATCOM in FY 2013.

(U) Program Plans:
FY 2009 Plans:

- Develop algorithms to identify moving targets and extract them from the data prior to imaging to avoid the streaking caused by their motions.
- Demonstrate algorithms on emulated data sets.

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	FY 2007	FY 2008	FY 2009
Bi-Static Shield	0.000	0.000	4.500

(U) The Bi-Static Shield will utilize existing satellite tracking, telemetry and control (TT&C) radio frequency (RF) illumination beams to create an electromagnetic (EM) shield in the immediate satellite vicinity (within a 30km radius from the geosynchronous orbit (GEO) satellite). Using the satellite omni antennas to serve as bi-static receivers, reflections from intruder satellites could be detected up to 10km from GEO spacecraft by extracting the very weak bi-static illumination signals reflected off the intruder satellites. Use of existing satellite TT&C transmit antennas to generate a bi-static EM shield would provide a very important situational awareness capability without the need for additional on-orbit assets around individual satellites. The Bi-Static Shield program is planned for transition to the Air Force for space situational awareness applications in FY 2012.

(U) Program Plans:

FY 2009 Plans:

- Conduct modeling and simulation to determine algorithms required.
- Develop software required to decipher received reflections.
- Upload and conduct over-the-air test using Tracking and Data Relay Satellite System (TDRSS) or other suitable cooperative satellite and satellite ground station.

	FY 2007	FY 2008	FY 2009
High Delta-V Experiment (HiDVE)	0.000	4.000	7.000

(U) The goal of the High Delta-V Experiment (HiDVE) program, an outgrowth of the MiDSTEP program, is to design, develop, and demonstrate a low-mass, low-volume, high delta-V solar thermal propulsion (STP) engine suitable for integration with a ~15kg nanosatellite host. The enabling technologies are very high-temperature materials and innovative receiver and concentrator designs. A HiDVE system will provide small satellites, historically constructed without propulsive capability, with substantial delta-V affording nanosatellites increased orbital range, in terms of both attitude and plane. In addition, this flexibility will be essential to future nanosatellite mission designers and operators, who will be

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able to take advantage of less-than-optimal insertion orbits and later move to an intended mission orbit. Specific objectives of the HiDVE program include: development and demonstration of a functioning STP system in a relevant environment; an operational test plan that outlines the steps needed to flight-qualify an integrated nanosatellite with an STP system.

- (U) Program Plans:
 FY 2008 Plans:
 – Develop a functioning high delta-V solar thermal propulsion system in a relevant environment.
 FY 2009 Plans:
 – Develop and ground demonstrate low-cost, low-volume solar thermal propulsion prototypes.

	FY 2007	FY 2008	FY 2009
Micro Electric Space Propulsion (MEP)	4.689	0.000	0.000

(U) The Micro Electric Space Propulsion program (MEP) would have demonstrated flexible, lightweight, 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.

- (U) Program Plans:
 FY 2007 Accomplishments:
 – Demonstrated core technology by showing sustained ion emission from an array of micro-fabricated microelectromechanical (MEMS) field effect electric propulsion (FEEP) thrusters.

(U) <u>Program Change Summary:</u> <i>(In Millions)</i>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
Previous President's Budget	253.950	224.551	225.238
Current Budget	222.300	216.419	287.009

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Total Adjustments	-31.650	-8.132	61.771
Congressional program reduction	0.000	-8.132	
Congressional increases	0.000		
Reprogrammings	-25.149		
SBIR/STTR transfer	-6.501		

(U) Change Summary Explanation:

FY 2007	Decrease reflects the Innovative Space-Based Antenna Technology (ISAT) reprogramming and the SBIR/STTR transfer.
FY 2008	Decrease reflects the cancellation of the MEP program and reductions for Section 8097 Contractor Efficiencies and Section 8104 Economic Assumptions.
FY 2009	Increase reflects funding of the Blackswift Test Bed and expansion of the System F6 and Sleight of HAND programs.

(U) Other Program Funding Summary Cost:

Falcon	FY 2007	FY 2008	FY 2009
PE 0604855, Air Force SPC	5.600	0.000	0.000
PE 0604856, Air Force SPC	26.500	23.500	11.000

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Deep View	FY 2007	FY 2008	FY 2009
PE 0305940F, Air Force SPC	13.576	8.859	0.000
 Space Surveillance Telescope	FY 2007	FY 2008	FY 2009
USAF	0.000	0.000	1.100

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