RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)				DATE February 2004			
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32				
COST (In Millions)	FY 2003	FY2004	FY2005	FY 2006	FY 2007	FY 2008	FY 2009
Total Program Element (PE) Cost	242.095	315.941	361.067	381.179	423.281	423.120	419.014
Advanced Aerospace Systems ASP-01	130.527	114.357	111.847	147.573	161.512	126.190	92.000
Space Programs and Technology ASP-02	111.568	201.584	249.220	233.606	261.769	296.930	327.014

(U) **Mission Description:**

(U) The Advanced Aerospace Systems program element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to dramatically reduce costs associated with advanced aeronautical and space systems and provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems, will be conducted.

(U) A number of aeronautical programs are funded in the Advanced Aerospace Systems project. The A160 Hummingbird Warrior program exploits a hingeless, rigid, rotor concept operating at the optimum rotational speed to produce a vertical take-off and landing unmanned air vehicle with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. The Canard Rotor/Wing aircraft program focuses on high-speed, rapid response vertical take-off and landing designs with improved range and stealth capabilities.

(U) Also funded within the Advanced Aerospace Systems project are several unmanned combat air vehicles. The Unmanned Combat Air Vehicle program focused on risk reduction and "Concept of Operation" evaluation. The Naval Unmanned Combat Air Vehicle program validated the technical feasibility for a naval unmanned combat air system to effectively and affordably perform naval Suppression of Enemy Air Defense/Strike/Surveillance missions. The results of these programs led to the formation of the DARPA/Air Force/Navy Joint-Unmanned Combat Air System. The goal of the Unmanned Combat Armed Rotorcraft program is to design, develop, integrate and demonstrate the enabling technologies and system capabilities required to perform mobile strike concept of operations. The Walrus program, an outgrowth of the Long Endurance Hydrogen Powered Unmanned Air Vehicle and the Unmanned Tilt Rotor programs, will develop and construct an Advanced Technology Demonstration Air Vehicle with comparable C-130 airlift capability.

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(U) The Space Programs and Technology Project is developing a space force structure that will be robust against attack. In addition to the ability to detect and characterize potential attacks, robustness against attack is provided by proliferation of assets, ready access to space 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. The Orbital Express Space Operations Architecture program will develop and demonstrate autonomous techniques for on-orbit refueling and reconfiguration of satellites that could support a broad range of future U.S. national security and commercial space programs. 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 Innovative Space-Based Radar Antenna Technology program addresses the technical and economic feasibility of developing space-based radar antennas necessary for tactical-grade ground moving target indicator performance from space. Deep view is developing a high-resolution radar imaging capability to characterize objects in the earth's orbit. The Responsive Access, Small Cargo, and Affordable Launch program will develop and demonstrate the capability to launch small satellites and commodity payloads into low-earth orbit. The High Frequency Active Auroral Research Project (HAARP) will develop new experimental research capabilities to exploit emerging ionosphere and radio science technologies related to advanced defense applications.

(U) An outgrowth of the space vehicle technologies and Hypersonics (TT-03) initiatives, the HyperSoar program will develop a dual use capability of an intercontinental global delivery vehicle and a first stage reusable space access vehicle. The Rapid On-orbit Anomaly Surveillance and Tracking program seeks to provide a space-based capability to detect and track on-orbit objects with rapid revisit rates and low latencies. The Tactically Responsive Satellites program will develop a spacecraft to provide high resolution imaging day or night using extremely lightweight optics and a compact design capable of being launched on a Pegasus air launch booster.

(U) **Program Change Summary:** *(In Millions)*	**FY 2003**	**FY 2004**	**FY2005**
Previous President's Budget	235.300	323.730	340.567
Current President's Budget	242.095	315.941	361.067
Total Adjustments	6.795	-7.789	20.500

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	FY 2003	FY 2004
Congressional program reductions	0.000	-9.289
Congressional increases	0.000	1.500
Reprogrammings	7.056	0.000
SBIR/STTR transfer	-0.261	0.000

(U) **Change Summary Explanation:**

FY 2003	Increase reflects program repricing and SBIR transfer.
FY 2004	Decrease reflects congressional reductions to space and hypersonic programs and undistributed reductions offset by an add for suborbital space launch operations.
FY 2005	Increase reflects additional funding for Walrus, Orbital Express, and several new space initiatives offset by repricing of several other aeronautics technology programs.

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Aerospace Systems ASP-01	130.527	114.357	111.847	147.573	161.512	126.190	92.000

(U) **Mission Description:**

(U) 'The Advanced Aerospace Systems project addresses high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems and provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted. Studies conducted under this project include examination and evaluation of emerging aerospace threats, technologies, concepts, and applications for missiles, munitions, and vehicle systems.

(U) **Program Accomplishments/Planned Programs:**

	FY 2003	FY 2004	FY 2005
Advanced Air Vehicle: A160 Hummingbird Warrior	13.645	9.500	9.000

(U) The A160 Hummingbird Warrior program will exploit a hingeless, rigid rotor concept operating at the optimum rotational speed to produce a vertical take-off and landing (VTOL) unmanned air vehicle (UAV) with low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (more than 2,000 nm) and/or endurance (24-48 hours). Detailed design, fabrication and testing of this vehicle is being conducted to establish its performance, reliability, and maintainability. The A160 concept is being evaluated for surveillance and targeting, communications and data relay, lethal and non-lethal weapons delivery, assured crew recovery, resupply of forces in the field, and special operations missions in support of Army, Navy, Marine Corps, and other Agency needs. It is being developed as a component of the DARPA/Army Future Combat Systems (FCS) Program. In addition, this program will evaluate application of the optimum speed rotor concept to other systems including heavy lift and tilt rotor capabilities. The program will also conduct development tests of heavy fuel engine technology and coordinate with other DARPA programs developing highly efficient heavy fuel engine technologies to further advance current range and endurance projections as well as improve operational reliability and

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logistics compatibility. In FY 2003, this program received additional funding from Congress ($1.614 million) to repair and upgrade Air Vehicle #1.

(U) Program Plans:
- Fabricate and test low vibration rotor modifications.
- Continue ground and flight test of A160 vehicles.
- Develop concept design of an unmanned ground vehicle deployment system for A160 vehicle.
- Perform conceptual design and trade studies of A160 variants for a variety of mission roles, including study of technology risk reduction, architecture, survivability, and command and control.
- Flight test low vibration four-blade rotor modifications.
- Conduct tests of advanced engines and coordinate with development of high-efficiency heavy fuel engine technologies.

	FY 2003	FY 2004	FY 2005
Unmanned Combat Air Vehicle (UCAV)	59.909	0.000	0.000

(U) DARPA and the Air Force jointly developed and funded the Unmanned Combat Air Vehicle (UCAV) System Demonstration Program (SDP) to demonstrate the technical feasibility, military utility, and operational value of a UCAV system to effectively and affordably prosecute lethal and non-lethal Suppression of Enemy Air Defense (SEAD) and strike missions within the emerging global command and control architecture. The overall purpose of the UCAV SDP was to design, develop, integrate, and demonstrate the critical technologies, processes, and system attributes pertinent to an operational UCAV system. The UCAV SDP is currently executing flight demonstrations with the X-45A air vehicle and is in the design phase for low observable robust prototypes. The results of this research led to the formation of the DARPA/Air Force/Navy Joint Unmanned Combat Air System.

(U) Program Accomplishments:
- Developed and demonstrated core UCAV functionality.
- Initiated design of next iteration low observable (LO) robust prototypes.
- Delivered two robust demonstration air vehicles.

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	FY 2003	FY 2004	FY 2005
Naval Unmanned Combat Air Vehicle (UCAV-N)	21.527	0.000	0.000

(U) The Naval Unmanned Combat Air Vehicle (UCAV-N) science and technology program validated the technical feasibility of naval unmanned combat air system effectively and affordably performing naval Suppression of Enemy Air Defense (SEAD)/Strike/Surveillance missions within the emerging global command and control architecture. This initiative investigated and validated the critical technologies, processes and system attributes associated with the development of a UCAV-N system. Analysis of the potential capability enhancements that would be realized by legacy force carrier air wings through the introduction of 12 to 16 carrier-capable, multi-mission Strike, SEAD and Surveillance unmanned combat aircraft was investigated. The program also emphasized a low life cycle cost combat effective design. The results of the program led to the formation of the DARPA/Air Force/Navy Joint-Unmanned Combat Air System.

(U) Program Accomplishments:
- Conducted demonstrations of technologies, processes, and systems attributes to demonstrate the feasibility of a low observable UCAV-N system capable of routine operation from aircraft carriers.
- Initiated detailed design of a demonstrator aircraft.

	FY 2003	FY 2004	FY 2005
Joint Unmanned Combat Air System (J-UCAS)	0.000	41.385	0.000

(U) The Joint Unmanned Combat Air System (J-UCAS) program is a joint DARPA, Air Force, and Navy effort to develop and demonstrate unmanned combat capabilities for high-threat Suppression of Enemy Air Defense (SEAD); Intelligence, Surveillance, and Reconnaissance (ISR); Electronic Attack (EA); and related strike missions within the emerging global command and control architecture.

(U) The J-UCAS program combines the efforts that were previously conducted under the DARPA/Air Force Unmanned Combat Air Vehicle (UCAV) program and the DARPA/Navy Naval UCAV (UCAV-N) program. Although these efforts were targeted towards Service-specific needs, the Department recognized the potential for significant synergy by combining the programs. The accomplishments and ongoing efforts of the

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X-45A technology demonstrator, as well as the development of the X-47A demonstrator, will reduce the risk of the system being developed for the operational assessment. The J-UCAS concept incorporates the Boeing X-45C/CN and Northrop Grumman X-47B air vehicles, together with a common architecture and subsystems (e.g. sensors, communications, and command & control software). These common system elements will maximize system flexibility and operational versatility, while reducing overall costs and maintaining schedule toward an Early Operational Assessment planned for the FY08-09 timeframe.

(U) The J-UCAS Office integrates DARPA, Air Force, and Navy personnel, operating in close coordination with Service users and other components. Service and DARPA funding for the J-UCAS in FY 2005 and subsequent fiscal years has been consolidated in two new program elements (PE 0603400D8Z and PE 0604400D8Z).

(U) Program Plans:

- Continue demonstrations with the X-45A to validate multi-vehicle coordinated operations and onboard intelligent software capable of dynamic retasking/replanning and distributed control beyond line of sight, with a robust contingency management system.
- Complete detailed design and initiate construction of the X-45C/CN and X-47B J-UCAS demonstrator aircraft.
- Initiate development of common system elements, including a common architecture and subsystems, to reduce risk and maintain schedule.
- Support development of Joint Service operational requirements and planning for the Early Operational Assessment phase of the program.

	FY 2003	FY 2004	FY 2005
Unmanned Combat Armed Rotorcraft (UCAR)	24.755	37.432	55.404

(U) The goal of the Unmanned Combat Armed Rotorcraft (UCAR) program is to design, develop, integrate and demonstrate the enabling technologies and system capabilities required to perform armed reconnaissance and attack missions within the Army's Objective Force system-of-systems environment. The enabling technologies are survivability, autonomous operations, command and control, and targeting/weapons delivery. A highly survivable UCAR system will prosecute enemy high value targets with relative impunity without placing a pilot in harm's way. UCAR's autonomous capabilities will enable effective teaming with manned systems and will eliminate the requirement for a dedicated ground control

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station. The UCAR capabilities will provide the Objective Force with the mobility, responsiveness, lethality, survivability, and sustainability required to ensure mission success. Specific objectives of the UCAR program include: development and demonstration of an effective, low total ownership cost design for the system; an air and ground-based command and control architecture for UCAR operations that does not require a dedicated ground control station; autonomous multi-ship cooperation and collaboration; autonomous low altitude flight; and system survivability.

(U) Program Plans:

- Continue system trades, effectiveness, and affordability analyses through modeling and simulation.
- Develop sufficient system concept fidelity to validate program goals and objectives.
- Complete the preliminary design and the Preliminary Design Review of the Demonstration System.
- Select one team for Phase III, System Demonstration.
- Initiate detailed design of the Demonstration System.
- Complete the Critical Design Review of the Demonstration System.
- Initiate fabrication of two UCAR Demonstrators.
- Perform component risk reduction demonstrations.

	FY 2003	FY 2004	FY 2005
Quiet Supersonic Platform	3.835	4.370	7.000

(U) The Quiet Supersonic Platform (QSP) program is directed towards development and validation of critical technology for long-range advanced supersonic aircraft with substantially reduced sonic boom, and increased efficiency relative to current-technology supersonic aircraft. Improved capabilities include supersonic flight over land without adverse sonic boom consequences with boom overpressure rise less than 0.3 pounds per square foot, increased unrefueled range approaching 6,000 nmi, gross take-off weight approaching 100,000 pounds, increased area coverage and lower overall operational cost. Highly integrated vehicle concepts were explored to simultaneously meet the cruise range and noise level goals. Advanced airframe technologies including optimized configuration shaping and laminar flow control were explored and shown to be viable to minimizing sonic boom and vehicle drag. The objective is to develop and demonstrate these technologies in a series of tests to validate performance. Work performed this past fiscal year included subscale model wind tunnel testing of low drag technology in a simulated flight environment and computational fluid dynamics calculations. In an effort to demonstrate configuration-shaping technology, plans were completed

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for a modified F-5 using a wing glove design. Once the flight test vehicle design was deemed suitable, parts fabrication and installation were completed. Flight tests successfully validated that optimized vehicle configurations produce shaped sonic boom signatures through the atmosphere to the ground. These flight tests demonstrated a low noise signature for supersonic aircraft.

(U) Program Plans:
- Conduct high fidelity wind tunnel test of large-scale semi span wing design to simulate actual supersonic flight conditions.
- Initiate preliminary design of laminar flow control technology integrated into flight test vehicle.
- Perform computational fluid dynamics calculations and conduct low and high speed wind tunnel tests of flight test vehicle to assess safety of flight.
- Conduct flight-testing to validate low drag technology in real flight environment.

	FY 2003	FY 2004	FY 2005
Canard Rotor/Wing (CRW)	3.233	11.763	14.542

(U) The Army, Navy, Air Force, and Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) air vehicles to support dispersed units. Canard Rotor/Wing (CRW) aircraft offer the potential for a high-speed, rapid response capability from a VTOL air vehicle with significant range and stealth improvements as compared to other VTOL concepts. Design, fabrication, ground and flight test of a scaled vehicle demonstrator will validate the stability and control system and aerodynamic performance required for vertical take-off, landing and hover via a rotating center wing that stops and locks in place for efficient high speed cruise. Following demonstration of the small scale vehicle, the program will proceed to design, development and demonstration of more operationally representative vehicles including manned aircraft.

(U) Program Plans:
- Conduct demonstrator flight tests.
- Begin design and development of follow-on manned and unmanned vehicles.

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	FY 2003	FY 2004	FY 2005
Cormorant Unmanned Air Vehicle (UAV)	0.000	0.000	2.984

(U) The Cormorant Unmanned Air Vehicle (UAV) program will examine the feasibility of a UAV that may be deployed from the sea without carrier support. The program will explore concepts that launch from both the sea surface and submarines. Technical challenges include aircraft dynamics at the air/sea interface, engine technology to survive periodic immersion in salt water, and development of advanced composite materials to withstand sea-surface operations. The Cormorant UAV is envisioned to provide close air support for vessels such as the Littoral Combo ship (LCS) and SSGN.

(U) Program Plans:
- Initiate feasibility studies; conduct modeling and simulation vehicle behaviors in the air/sea interface.
- Explore novel composite materials.

	FY 2003	FY 2004	FY 2005
Heavy Fuel Enginefor A160	2.144	4.426	4.687

(U) The Heavy Fuel Engine for A160 program will develop and demonstrate a heavy-fuel, lightweight, and efficient engine for the A160 air vehicle. In the future, heavy fuel (diesel or JP-8) will be the only logistic fuel for the battlefield. Conventional heavy-fuel engines are too heavy for air vehicles and, at the desired size, not efficient enough. Innovative and advanced diesel engine concepts will be developed to achieve both efficiency and a significant reduction in weight. An engine will enable the A160 to achieve maximum range and endurance while operating on diesel fuel.

(U) Program Plans:
- Detail design of the engine.
- Demonstrate performance goals of a prototype engine at 33% efficiency and a power to weight ratio of 0.83 hp/lb.
- Demonstrate performance and reliability of optimized engines at 39% efficiency and a power to weight ration of 1.0 hp/lb.

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	FY 2003	FY 2004	FY 2005
Walrus	0.000	0.000	10.000

(U) This work is a continuation of technologies and concepts previously developed and reported under PE 0602702E, Tactical Technology Project TT-07, Aeronautics Technology. The Walrus program will develop and evaluate a very large airlift vehicle concept that is designed to fly heavier-than-air, unlike earlier generation airships. As a "hybrid aircraft," it will generate lift through a combination of aerodynamics and gas buoyancy. The program will develop and construct a Walrus Advanced Technology Demonstration (ATD) air vehicle with comparable C-130 airlift capability, and will explore, develop, and demonstrate the system concepts of operation. Scalability of the concept will also be demonstrated. An objective vehicle is envisioned to be capable of lifting over 500 tons across intercontinental distances, being able to transport a Unit of Action (UA) from "Fort-to-Fight" as a complete integrated action-ready package of personnel and equipment. Additionally, Walrus may meet the multi-agency needs of common requirements for extended range airborne patrol, persistence and intra-theater support and re-supply. Two advanced breakthrough technologies that will be investigated in the first phase are: vacuum / air buoyancy compensator tanks, and electrostatic atmospheric ion propulsion. The program's first phase will include system studies and development of a notional concept of the objective vehicle. Based on these studies and concept viability, the competitive second phase will lead to development, design, build and initial flight test of the ATD vehicle.

(U) Program Plans:

- Development of the objective air vehicle design, operational requirements and CONOPs.
- Competitive development of system requirements and preliminary ATD vehicle design based on selected concept options.
- Risk reduction testing in support of ATD and objective air vehicles.
- Complete detailed design ATD air vehicle continuing on to a critical design review.
- Manufacture and fabricate ATD air vehicle.
- Flight test and release to Services for evaluation testing of military utility.

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	FY 2003	FY 2004	FY 2005
Critical Munition Capability	0.000	2.500	3.500

(U) The Critical Munition Capability program consists of three efforts: HyperJAM (Hypersonic Joint Attack Munition), MAULLM (Multi-target AUtonomous Loitering Littoral Munition), and BEDLAM (Battlefield Electronically Disruptive Loitering Attack Missile). The goal of each of these efforts is to provide the warfighter with a range of weapons that enable effective, precise, responsive, and decisive disruption to enemy forces. The MAULLM and BEDLAM programs build upon developments from the NetFires program previously funded from PE 0603764E, Land Warfare Technology, Project LNW-03.

(U) HyperJAM provides the capability to deliver GPS precision guided weapons to high value, well defended, and relocatable targets with range capability in excess of 400 nm. HyperJAM uses conventional rocket technology (black brandt rocket) integrated with a modified aerodynamically enhanced Joint Direct Attack Munition (JDAM) high speed nosecone to deliver MK84 munitions to precise locations. Utilization of a zoom maneuver from a high performance aircraft (F-16, F/A-18) allows delivery of an air-to-surface weapon on a ballistic trajectory that greatly enhances its range capability with the same lethality/accuracy.

(U) MAULLM will develop and test a containerized, platform-independent multi-mission weapon concept that will provide rapid response and lethality in packages with significantly lower missile unit cost, decreased logistical support and lower life-cycle costs, while increasing flexibility compared to current Naval gun and missile systems. MAULLM will address current Naval threats such as massed, swarming suicide attack boats, and will significantly enhance operations ashore by providing a long-loiter, on-call weapon capable of engaging multiple (~10) individual targets. MAULLM builds on and extends many of the concepts developed in NetFires, will be air deployable in C-130 (and smaller) aircraft, and will enhance the situation awareness and survivability of the Navy and Marines by providing standoff target acquisition and extended-range, non-line-of-sight engagements. The program will develop and demonstrate a highly flexible, modular, multimission loitering missile that can be remotely commanded and can send target detection and battle damage information back to the controller.

(U) BEDLAM will develop critical components and technologies for detection, exploitation, and disruption of a wide variety of enemy electronic emissions and will integrate them into a mission module suitable for use on small loitering missiles. The program will develop or enhance a number of key components: extremely sensitive transceivers capable of detection of extremely low-level electronic signals; signal processing algorithms to separate signals of interest from other electronic clutter; direction finding and mapping techniques to track multiple

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emitters; and antenna arrays suitable for wide-frequency operation; and will integrate these elements into a mission module suitable for small loitering missiles or UAVs. If successful, this will provide improved capabilities in several areas: a single missile can detect and engage air defense assets even after they cease transmissions or begin to move; low-level emissions from cell phones and computer networks can be detected and relayed or targeted; and target-specific emissions detected by other systems (such as Wolfpack) can be acquired and correlated with other co-located emissions even while moving to establish patterns or meetings with other emitters to aid in intelligence and targeting. This program will leverage both the DARPA NetFires and Wolfpack programs.

(U) Program Plans:

- HyperJam
  - -- Develop system level requirements.
  - -- Conduct detailed simulation studies to determine range capability and control requirements.
  - -- Develop integrated missile concepts with modified Joint Direct Attack Munition (JDAM) for attitude control.
  - -- Conduct ground experiments to simulate attitude control capability and aerodynamic environment.
  - -- Conduct flight experiments on F/A-18 to demonstrate integrated system performance.

- MAULLM
  - -- Initiate competitive contracts for system preliminary design.
  - -- Develop and demonstrate critical technologies including next-generation Automatic / Assisted Target Recognition and novel low-cost reduced-signature airframe concepts.
  - -- Evaluate communication and command and control technologies and select best option(s).
  - -- Evaluate preliminary designs and downselect to best design(s).
  - -- Develop brassboard seekers and submunitions and perform flight tests against a variety of targets.
  - -- Downselect or modify design based on flight test data and develop form factored MAULLM prototype.
  - -- Perform flight tests with loitering missile in simulated military mission.

- BEDLAM
  - -- Initiate competitive contracts for system preliminary design.
  - -- Obtain and present data from representative emitters to determine performance boundaries.
  - -- Evaluate emerging antenna concepts and select best option(s).

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-- Evaluate preliminary designs and downselect to best design(s).
-- Develop brassboard module and perform flight tests against a variety of emitters.
-- Downselect or modify designs based on flight test data and develop formfactored module for loitering missile.
-- Perform flight tests with loitering missile in simulated military mission.

	FY 2003	FY 2004	FY 2005
Modular Blended Wing Body Multi-Role Aircraft (MBWB MRA)	0.000	0.000	3.420

(U) The goal of the MBWB MRA program is to develop and demonstrate a system that can efficiently and affordably meet the Joint Service needs for a bomber, tanker, and transport. The inherently high lift-to-drag ratio and payload fraction of the MBWB MRA will enable weapons, fuel, materiel, and personnel to be transported 25-50 % more efficiently than is possible with current aircraft. The MBWB MRA will be reconfigurable on the flight line to a bomber, tanker, or transport in less than 24 hours. Commercial derivatives of the MBWB MRA will carry freight at a cost per air ton mile that is 20-40 % below that of existing aircraft.

(U) This program will develop and demonstrate technology to enable large scale composite manufacturing, advanced flight controls, modular payloads, and separation of stores. Structural characteristics will be validated through destructive testing of panels. Aerodynamic control, store separation, and aerodynamic performance will be demonstrated through wind tunnel models. A 40-50 % scale aircraft will be designed, fabricated, and demonstrated.

(U) Program Plans:
- Perform system trades and develop conceptual designs.
- Develop large scale composite manufacturing technology.
- Develop modular mission modules.
- Develop aerodynamic control technologies.
- Develop store separation technology.
- Fabricate a 40-50 %scale model of a MBWB MRA.
- Demonstrate capability to reconfigure as a bomber, tanker, and transport.

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– Demonstrate efficiency and affordability.

	FY 2003	FY 2004	FY 2005
Advanced Aerospace System Concepts	1.479	2.981	1.310

(U) Studies conducted under this project examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact/improvements to military operations, mission utility, and war fighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate new programs or refocus ongoing work. Topics of consideration include: methods of defeating enemy anti-aircraft attacks; methods to intercept and defeat enemy unmanned air vehicles (UAVs); munition technologies to increase precision, range, endurance and lethality of weapons for a variety of mission sets; novel launch systems; and air vehicle control, power, propulsion, materials, and architectures.

(U) Program Plans:
- Perform studies of candidate technologies and develop system concepts.
- Conduct modeling and simulation of system architectures and scenarios.
- Conduct enabling technology and sub-system feasibility experiments.

(U) **Other Program Funding Summary Cost:**

Unmanned Combat Air Vehicle (UCAV)	FY 2003	FY 2004	FY 2005
PE 0603333F, Air Force	17.608	0.000	0.000
PE 0604731F, Air Force	36.756	0.000	0.000
PE 0207256F, Air Force	0.000	0.000	0.000

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Naval Unmanned Combat Air Vehicle (UCAV-N)	FY 2003	FY 2004	FY 2005
PE 0603114N	20.280	0.000	0.000

Joint Unmanned Combat Air System (J-UCAS)	FY 2003	FY 2004	FY 2005
PE 0604731F, Air Force	0.000	174.449	0.000
PE 0207256F, Air Force	0.000	2.305	0.000
PE 0603114N, Navy	0.000	117.865	0.000
PE 0603400D8Z, OSD	0.000	0.000	284.617
PE 0604400D8Z, OSD	0.000	0.000	422.873

Unmanned Combat Armed Rotorcraft (UCAR)	FY 2003	FY 2004	FY 2005
PE 0602211, Project 47A, Army	10.000	0.000	0.000
PE 0603003, Project 313, Army	0.000	14.000	20.000

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Space Programs and Technology ASP-02	111.568	201.584	249.220	233.606	261.769	296.930	327.014

(U) **Mission Description:**

(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.

(U) **Program Accomplishments/Planned Programs:**

	FY 2003	FY 2004	FY 2005
Orbital Express Space Operations Architecture	39.614	55.110	56.599

(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 nanosatellites for inspection to provide data to support

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satellite repair. The Orbital Express advanced technology demonstration will design, develop and test on-orbit a prototype servicing satellite (ASTRO), a surrogate next generation serviceable satellite (NextSat), and the Space Awareness prototype micro-satellite escort, that will provide near-field space situation awareness for U.S. satellites deployed in geo-stationary orbits. The elements of the Orbital Express demonstration 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 Orbital Space Plane and to enable future commercial resupply of the International Space Station. 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.
- Design, fabricate and test on orbit a modular micro-satellite for protection of U.S. geo-stationary satellites.
- 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.

	FY 2003	FY 2004	FY 2005
Space Surveillance Telescope	3.966	8.921	16.673

(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.

(U) Program Plans:
- Fabricate and test first curved focal plane tile.
- Fabricate remaining sensor elements.

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- Begin optics fabrication.
- Begin wide-field camera integration.
- Begin telescope integration.
- Complete site selection.

	FY 2003	FY 2004	FY 2005
Innovative Space-Based Radar Antenna Technology (ISAT)	16.699	41.208	45.000

(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 ultra lightweight low-power density RF electronics. An antenna of this size enables a medium Earth orbit (MEO) constellation that provides 24/7 true continuous coverage with as few as eight satellites, as compared to many dozens at low Earth orbit (LEO). In particular, 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 rigidized inflatable structures, and will develop performance predictions on the selected designs as well as lifecycle cost models. These designs will be down selected to carry out a space-based experiment of the critical technologies.

(U) Program Plans:

- Develop next-generation lightweight electronics, materials and deployment structures.
- Perform ground-based risk reduction experiments for packaging and deployment mechanisms and materials, including simulation of mechanical and thermal loads.
- Complete systems designs for space-based experiment; downselect to single design; build, integrate and demonstrate space-based tactical-grade aperture technology.

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	FY 2003	FY 2004	FY 2005
Microsatellite Tactical Communications Network	0.000	0.000	4.900

(U) The aim of the Microsatellite Tactical Communications Network (MTCN) effort is the development of advanced, affordable, robust anti-jam satellite communications. This will be accomplished through novel microsatellite spacecraft design, advanced low-weight, highly compactable antennas, and novel cooperative multi-satellite coherent signal combining. Moreover, novel launch vehicle integration and electronic propulsion concepts will be developed that may allow for the deployment of an entire constellation from a single launch.

(U) Program plans:
- Develop novel MTCN system and spacecraft designs.
- Develop novel launch dispenser concepts, possibly enabling single launch deployment of the entire constellation.
- Determine feasibility of novel signal processing concepts to enable robust comms on small platforms.
- Carry out ground-based proof-of-concept demonstrations.

	FY 2003	FY 2004	FY 2005
Deep View	3.976	9.520	11.000

(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 to geo-stationary orbit. 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 transmitters capable of providing the required power to image at deep-space ranges over full bandwidth and antenna design that maintains 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.

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(U) Program Plans:
- Perform transmitter power combiner experiments.
- Complete transmitter design and radar system design.
- Begin signal processing software development.

	FY 2003	FY 2004	FY 2005
Responsive Access, Small Cargo, Affordable Launch (RASCAL)	24.374	30.302	39.750

(U) The Responsive Access, Small Cargo, Affordable Launch (RASCAL) program will design and develop a low cost orbital insertion capability for dedicated micro-size satellite payloads. The concept is to develop 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 will be comprised of 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 objectives are to place satellites and commodity payloads, between 50 and 130 kilograms in weight, into low-earth orbit at any time, with launch efficiency of $20,000 per kilogram or less. While the cost goal is commensurate with current large payload launch systems, the operational system, through production economies of scale, will be more than a factor of three less than current capabilities for the dedicated micro payload size. This capability will 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. This program will utilize reusable aircraft technology for the first stage and will take advantage of low-cost rocket technologies for the expendable upper stages. With recent advances in design tools and simulations, this program will prudently reduce design margins and trade-off system reliability to maximize cost effectiveness. This program will also leverage advancements in autonomous range safety, first-stage guidance; and predictive vehicle health diagnosis, management and reporting to lower the recurring costs of space launch.

(U) Program Plans:
- Develop Contractor Life Cycle Cost Model (CLCC).
- Prototype Mass Injection Pre-compressor Cooling (MIPCC) manifold – engine testing.
- Select preferred system concept(s).
- Establish Preliminary and Critical Design of full system.
- Conduct mission cycle testing of the first-stage MPV propulsion in direct connect wind tunnel.

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- Conduct early Risk Reduction testing of subsystems: J-85 and F-100 turbine engine testing with MIPCC for thrust augmentation, aircraft wind tunnel for stability, scaled static fires of hybrid motors, Guidance, Navigation & Control (GN&C) simulation, material coupon testing, and Reaction Control System (RCS) firing.
- Conduct static fire of potential new rocket motor in flight weight configuration.
- Flight test MIPCC equipped aircraft.
- Integrate low cost expendable rocket vehicle and common head steering stage design.
- Develop instrumentation package for maiden payload.
- Conduct two orbital insertion missions for final demonstration.

	FY 2003	FY 2004	FY 2005
Tactically Responsive Satellites (TRS)	2.032	5.016	3.800

(U) The TRS program (formerly titled Low Cost Tactical Imager) 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 to be developed 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.

(U) Program Plans:
- Develop candidate designs for tactically responsive warfighter payloads.
- Develop and mature key enabling technologies.
- Perform ground-based risk reduction experiments including rapid checkout functionality.
- Design, build and integrate space-based prototype.

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	FY 2003	FY 2004	FY 2005
Force Application and Launch from CONUS (FALCON)	7.500	17.500	25.000

(U) The FALCON (formerly HyperSoar) program objectives are to develop and demonstrate technologies that will enable both near-term and far-term capability to execute time-critical, global reach missions. Near-term capability will be accomplished via development of a rocket boosted, expendable munitions delivery system that delivers its payload to the target by executing unpowered glide maneuvers at hypersonic speed. This concept called the Common Aero Vehicle (CAV) would be capable of delivering up to 1,000 pounds of munitions to a target at global distance. A Small Launch Vehicle (SLV) will place CAV at the required altitude and velocity. The FALCON program will develop a low cost, responsive SLV that meets these requirements and demonstrate this capability in a series of flight tests culminating with the launch of a functional CAV. In addition, this SLV will be capable of launching small satellites into sun synchronous orbit. Far-term capability is envisioned to entail a reusable, hypersonic cruise vehicle (HCV) capable of delivering 12,000 pounds of payload to a target 9,000 nautical miles from CONUS in less than two hours. Many of the technologies required by CAV are also applicable to this HCV concept such as high lift-to-drag technologies, high temperature materials, thermal protection systems, and periodic guidance, navigation, and control. Initiated under the Space Vehicle Technologies program, and leveraging technology developed under the Hypersonics Flight (HyFly) program, FALCON will build on these technologies to address the implications of powered hypersonic flight and reusability required to enable this far-term capability. The FALCON program addresses many high priority mission areas and applications such as global presence, space control, and space lift.

(U) Program Plans:

- Complete Common Aero Vehicle (CAV) and Small Launch Vehicle (SLV) system designs.
- Perform periodic trajectory analysis for Hypersonic Cruise Vehicle (HCV).
- Complete HCV system level design.
- Initiate preliminary design of CAV and SLV.
- Perform technology validation for reusable, hypersonic aircraft.
- Conduct critical design review of CAV and SLV, and initiate fabrication.
- Initiate preliminary design of the HCV technology flight demonstration vehicle.
- Conduct CAV flight demonstrations using existing boosters.
- Conduct SLV flight demonstration.

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- Conduct integrated CAV/SLV flight test.
- Conduct critical design review of HCV demonstration system and initiate fabrication.
- Conduct flight-testing of advanced reusable technologies for HCV.

	FY 2003	FY 2004	FY 2005
Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST)	0.000	5.000	5.000

(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, adaptive focal plane array sensors, and efficient space-qualified receivers and processors. The system will feature space-craft technologies, such as structure-integrated propellant tanks and liquid metal reaction wheels, to produce a spacecraft capable of launch from a RASCAL 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 optics fabrication capability.
- Demonstrate prototype integrated tanks and liquid reaction wheels.
- Complete telescope design.
- Complete blue force tracking receiver.
- Complete focal plane array design lay-out.
- Complete spacecraft PDR.

	FY 2003	FY 2004	FY 2005
High Frequency Active Auroral Research Project (HAARP)	11.034	16.093	15.006

(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

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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. Basic and exploratory development research programs are now being conducted routinely with it. 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 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.

(U) An April 2001 Defense Threat Reduction Agency (DTRA) Study indicated that a single low-yield (10-20 kt), high-altitude (125 - 300 km) nuclear detonation (HAND) would enhance the magnetospheric high energy particle density by three orders of magnitude or more, and persist for over a year. This event would disable all low earth orbit (LEO) satellites not specifically hardened to withstand radiation generated by that explosion. The resultant loss of communications, imaging, and weather satellites would have catastrophic global security and economic impacts. Replacing the lost inventory after the fact would cost in the trillions of dollars. The cost of hardening new satellites is also prohibitive. The probability of such an asymmetric threat is not negligible, given the recent nuclear weapon activities in Asia, and the consequences of such a threat are disastrous. HAARP will provide a ground-based testbed for early feasibility examination and tradeoffs of concepts for accelerating the reduction of HAND-enhanced charged particle populations in the radiation belts. Two concepts will be considered: (1) space-based propagation of very low frequency (VLF) electromagnetic waves into the ionosphere in the magnetic field line where the trapped particles are oscillating between magnetic mirror points, causing the particles to be "swept away" ten times faster than the natural decay; and (2) high voltage multi-kilometer Electrodynamic/Static (ED/ES) space tethers to remove highly charged trapped radiation particles as they traverse the magnetic field lines. In both concepts, HAARP would be used to establish the optimum electromagnetic wave/tether parameters for an operational system that could be based on the ground, in space, or both.

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(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 2003	FY 2004	FY 2005
Suborbital Space Launch Operations	2.373	1.500	0.000

(U) The goal of the Suborbital Space Launch 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, fabricate and test a restartable modular propulsion system capable of providing both ascent and descent propulsion.
- Demonstrate propulsion system operation including restart without maintenance or refueling.
- Analyze trade space for a technology demonstrator.

	FY 2003	FY 2004	FY 2005
Space Assembly and Manufacture	0.000	4.200	4.792

(U) The goal of the Space Assembly and Manufacture program is to examine and validate technical options for manufacturing 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, nanotube

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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. The program will then culminate in a flight demonstration of a space tug with robotic docking and repositioning in FY 2008. 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.
- Develop imaging, guidance and grappling algorithms and software.
- 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 2003	FY 2004	FY 2005
Electro-Dynamic Tethers	0.000	0.000	2.800

(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 provides 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:

- Compete analytical analysis for tether HAND remediation, propulsion and power generation performance expectation.
- Ground test key high-voltage electro-static-like tether components.
- Flight qualify tether space flight experiments payload for placement on a small, high-powered satellite bus.
- Launch and execute tether experiments in LEO: natural-radiation-belt, high-energy electron remediation; orbit-raising and lowering; peak- power production and high-fidelity ground tracking.

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	FY 2003	FY 2004	FY 2005
Micro Electric Space Propulsion	0.000	0.000	3.800

(U) The Micro-Electric Space Propulsion program 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.

(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 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 2003	FY 2004	FY 2005
RAD Hard by Design	0.000	7.214	10.500

(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 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

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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. In FY 2003, this program was funded from PE 0603739E, Project MT-15, Advanced Electronics Technology. The program was moved to Advanced Aerospace Systems because of the applicability of radiation hardened electronics to space applications.

(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 2003	FY 2004	FY 2005
Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP)	0.000	0.000	4.600

(U) The Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) program, expanding on a thrust area initiated under the Space Assembly and Manufacture program (same PE and project), will develop advanced technologies and capabilities required to demonstrate in a Low Earth Orbit (LEO), Medium Earth Orbit (MEO), and the deep space (Super GEO) environment a suite of advanced lightweight microsatellite (spacecraft dry mass on the order of 100 kg) technologies integrated into a high performance microsatellite. 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. Technologies 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 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, and may serve as a testbed for a variety of potential microsatellite applications.

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(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.

(U) **Other Program Funding Summary Cost:**

Orbital Express Space Operations Architecture	FY 2003	FY 2004	FY 2005
NASA	9.000	8.000	0.000

High Frequency Active Auroral Research Project (HAARP)	FY 2003	FY 2004	FY 2005
PE 0601153N, Navy	12.500	15.000	16.000
PE 0602601F, Air Force	0.000	10.000	10.000

Force Application and Launch from CONUS	FY 2003	FY 2004	FY 2005
PE 0604855, Air Force SPC	0.000	24.440	35.362
PE 0604856, Air Force SPC	0.000	12.220	21.610