RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	**R-1 ITEM NOMENCLATURE** Advanced Aerospace Systems PE 0603285E, R-1 #36

COST *(In Millions)*	FY 2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	38.093	153.700	246.000	394.662	485.549	527.931	678.363	Continuing	Continuing
Advanced Aerospace Systems ASP-01	38.093	153.700	132.000	157.106	154.684	158.337	167.903	Continuing	Continuing
Space Programs and Technology ASP-02	0.000	0.000	114.000	237.556	330.865	369.594	510.460	Continuing	Continuing

(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 Supersonic Miniature Air-Launched Interceptor program will demonstrate an inexpensive supersonic air platform with a low cost infrared sensor to provide cruise missile defense. 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 unmanned air vehicle with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. The Quiet Supersonic Platform program is directed towards development and validation of critical technology for long-range advanced supersonic aircraft with substantially reduced sonic boom, reduced takeoff and landing noise, and increased efficiency relative to current-technology supersonic aircraft.

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(U) Also funded within the Advanced Aerospace Systems project are several unmanned combat air vehicles. The Unmanned Combat Air Vehicle program continues to focus on risk reduction and "Concept of Operation" evaluation. The goal of the Naval Unmanned Combat Air Vehicle advanced technology demonstration program is to validate 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 goal of the Unmanned Combat Armed Rotocraft program is to design, develop, integrate and demonstrate the enabling technologies and system capabilities required to perform mobile strike concept of operations.

(U) The Space Programs and Technology Project focuses on a space force structure that is 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. The Space Vehicle Technologies program will pursue advances in space power, propulsion, maneuvering, navigation, communications and other spacecraft subsystems. The Advanced MEMS Technologies program seeks to demonstrate MEMS based technologies for space-based applications. Initially funded in the Tactical Technology program element in FY 2002, the Rapid Access, Small Cargo, Affordable Launch program that will develop and demonstrate the capability to launch small satellites and commodity payloads into low-earth orbit. The Tactical Optical Sensing program will develop both moving target indications over a wide area and high resolution imaging over a small area with the same optical sensor. The Low Cost Tactical Imager 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. The Tactical Pointing Determination of Imaging Spacecraft program will develop relocatable space surveillance radar to provide near-real time pointing determination of imaging spacecraft to the warfighter.

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

	FY 2001	FY 2002	FY 2003
FY02 Amended President's Budget	37.474	153.700	64.000
Current Budget	38.093	153.700	246.000

(U) Change Summary Explanation:

FY 2001 Increase reflects minor program repricing.

FY 2003 Increase reflects full funding of the Unmanned Combat Air Vehicle and major expansion of space programs initiated in FY 2002.

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COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Advanced Aerospace Systems ASP-01	38.093	153.700	132.000	157.106	154.684	158.337	167.903	Continuing	Continuing

(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.

(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 with very 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 unmanned air vehicle (UAV) range (more than 2,000nm) and endurance (24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance. The A160 concept is being evaluated for surveillance and targeting, communications and data relay, lethal and non-lethal weapons delivery, assured crew recovery and special operations missions in support of Navy, Marine Corps, Army and other Agency needs. 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 develop highly efficient heavy fuel engine technologies to further advance current range and endurance projections as well as improve operational reliability and logistics compatibility.

(U) 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. An important element of the program is the enabling nature of such capability for new space missions and its potential to reduce space program costs through spacecraft life extension ("Pre Planned Product Improvement," or "P3I"), comparable to what is done today with aircraft. During Phase I (Concept Definition) the type of satellite servicing to be emulated in the on-orbit demonstration will be identified (to include the type of hardware upgrades and reconfiguration to be supported, and the techniques to be adopted in transferring hardware and fuel between spacecraft), and detailed designs will be developed for "industry standard," nonproprietary satellite-to-satellite mechanical and electrical interfaces enabling on-orbit hardware and fluid transfers. Concepts for auxiliary missions for a servicing spacecraft, such as supporting operations of micro-satellites, will also be developed. A preliminary system design will emerge in conjunction with developments in software and sensors necessary for autonomous space operations to

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assess the potential significant cost savings for space operations. In Phase II, detailed design of the on-orbit demonstration spacecraft (the service vehicle, the demonstration "target," or serviced satellite, and the depot for replacement hardware and fuel) will occur and the spacecraft will be fabricated, integrated, ground tested, and space-qualified. In FY 2005, the demonstration spacecraft will be launched. On-orbit, the Orbital Express spacecraft will repeatedly demonstrate the feasibility of autonomously upgrading, refueling and reconfiguring satellites. Following an initial 4-6 month demonstration, the Orbital Express demonstration system will be transitioned to a follow-on customer for additional test and evaluation. In FY 2003, this program will be funded in Project ASP-02, Space Programs and Technology.

(U) The joint DARPA/Air Force Unmanned Combat Air Vehicle (UCAV) program will continue risk reduction and "Concept of Operation" evaluation for the Unmanned Combat Air Vehicle. Specifically, this program will continue the design and begin fabrication of the SystemB demonstrator (X-45B Low Observable air vehicle, mission control system and support segment), begin development of its tailored sensor and communications suite, and continue spiral system software development. Ultimately, this program will support the goal to demonstrate the technical feasibility, military utility and operational value of a UCAV system to effectively and affordably perform Suppression of Enemy Air Defense (SEAD)/Strike missions in the 2010 timeframe.

(U) The goal of the Naval Unmanned Combat Air Vehicle (UCAV-N) advanced technology demonstration program is to validate the technical feasibility for a naval unmanned combat air system to effectively and affordably perform naval Suppression of Enemy Air Defense (SEAD)/Strike/Surveillance missions within the emerging global command and control architecture. This advanced technology demonstration initiative will investigate and validate the critical technologies, processes and system attributes associated with the development of a UCAV-N system. The proposed UCAV-N design will be suitable for aircraft carrier use; however, will also stress maximum commonality with the Air Force UCAV. Analysis of the legacy force carrier air wing together with an additional 12 to 16 multi-mission Strike, SEAD and Surveillance unmanned combat aircraft that are suitable for aircraft carrier use and capable of penetrating fully operational enemy air defense systems are areas of investigation. It is also important to develop and demonstrate a low life cycle cost combat effective design for a multi-mission Strike, Suppression of Enemy Air Defense (SEAD) and Surveillance unmanned air vehicle while demonstrating robust and secure command, control and communications peculiar to the maritime environment, including line-of-sight, non-line-of-sight, and over-the-horizon.

(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, reduced takeoff and landing noise, 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

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100,000 pounds, increased area coverage and lower overall operational cost. Highly integrated vehicle concepts will be explored to simultaneously meet the cruise range and noise level goals. Advanced airframe technologies will be explored to minimize sonic boom and vehicle drag including natural laminar flow, aircraft shaping, plasma, heat and particle injection, and low weight structures.

(U) Both the U.S. military and economy increasingly depend on space platforms for command, control, communications, intelligence, surveillance, reconnaissance, meteorology, navigation and other functions. With this increasing dependence comes increased vulnerability to attack on space platforms and their ground based infrastructures. This project is also developing technologies that enable survivable and robust space systems. The project consists of: Space Protection and Warning (SPAWN); Space Battle Management Command, Control and Communications ($SBMC^3$); and Deep View. The SPAWN, $SBMC^3$, and Deep View programs are closely coordinated with the Air Force and USCINCSPACE, and with DARPA's Advanced Space Surveillance Telescope (PE0603762E, Project SGT-02), Orbital Express, and classified programs.

(U) The Satellite Protection and Warning (SPAWN) program will examine the use of microsatellites to provide enhanced situational awareness for U.S. space assets. Functions will include self-inspection, characterization, space environment monitoring, and diagnosis of spacecraft anomalies. A key element of this program will be the use of a modular satellite architecture to enable rapid integration of multiple payload combinations in response to varying mission requirements. In Phase I, a range of satellite warning and protection functions will be analyzed and ranked in order of utility, such as situational awareness, self-inspection, and characterization. A preliminary system design will detail the number, types and configurations of sensors as well as the software required for characterization and assessment, which will generate status reports and anomaly alerts. A high degree of autonomous operation, with reporting only on significant events or requests from the ground, will be a key objective. In Phase II, detailed designs of the on-orbit demonstration spacecraft will occur and the spacecraft will be fabricated, ground tested, and space-qualified. Finally, in FY 2005, the SPAWN demonstration spacecraft will be launched and engaged in a series of on-orbit demonstrations. In FY 2003, this program will be funded in Project ASP-02, Space Programs and Technology.

(U) The Space Battle Management Command, Control and Communications ($SBMC^3$) program will develop computing and communications technologies that will enable space forces to dominate the battlespace through automated spacecraft tracking and control, fusion of space surveillance sensor information, and assured command and control of space assets. $SBMC^3$ will provide algorithms that enable correlation and handoff of data between space sensors of widely different sensing modalities, locations and reporting intervals. Protocols for information exchange within the space control architecture will be optimized. Information systems for highly automated space object tracking, identification and activity assessment will be developed. The space battle management architecture will feature streamlined human interaction for more rapid action timelines

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and reduced error rates, in an environment of ever increasing numbers of sensors being controlled and objects being tracked, while maintaining assured human control of space activities. In FY 2003, this program will be funded in Project ASP-02, Space Programs and Technology.

(U) The Deep View program (formerly entitled the "Space Object Identification System") will develop a high-resolution radar imaging capability to characterize objects in earth orbit. A special emphasis will be placed on imaging small, faint 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 to GEO 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. In FY 2003, this program will be funded in Project ASP-02, Space Programs and Technology.

(U) The Space Technologies Program will develop and demonstrate advances in smart materials, multifunctional materials and power electronics to provide gains in the performance of space structures and systems. This work will include materials, devices and novel structural systems that will allow for large scale changes in shape and function with minimal energy/power requirements for shape control, and adaptation on-orbit to precisely align highly packaged spacecraft. This task will also demonstrate an electronics module that utilizes the hybridization of cryogenic, superconducting and conventional room temperature power electronics for optimum performance of satellite systems. This hybridization translates to modules with increases of efficiency of factors of two to four, at least ten times lower system noise and significant reductions in size and weight that scale with the overall size of the system.

(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 the mobile strike concept of operations 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. In addition, a UCAR capability will provide the Objective Force with the mobility, responsiveness, and lethality 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 UCAR system; an air and ground-based command and control architecture for UCAR operations; autonomous multi-ship cooperation and collaboration; autonomous low altitude flight; and UCAR system survivability.

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(U) The Supersonic Miniature Air-Launched Interceptor (MALI) program demonstrated an inexpensive supersonic air platform with a low cost infrared (IR) sensor to provide cruise missile defense by exploiting large rear aspect IR signatures and overtaking incoming missiles from the rear. The program leveraged off the miniature air-launched decoy (MALD) program's technology and off board surveillance and tracking sensors to provide tail-on missile end game opportunities. An advanced unmanned air vehicle avionics development and emerging payload effort was incorporated into the MALI core program due to the required data transmit/receive survivability configuration of the interceptor mission.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2001 Accomplishments:</u>

- Advanced Air Vehicle: Hummingbird Warrior. ($3.700 Million)
  - Initiated ground and flight test-phase of A160 air vehicle.
  - Designed sensor integration modifications to A160 air vehicle.
  - Designed low-vibration rotor modifications for A160.
  - Designed unmanned ground vehicle deployment system for A160.
  - Studied A160 scaling and signature reduction.

- Supersonic Miniature Air-Launched Interceptor (MALI). ($7.708 Million)
  - Completed air vehicle fabrication, assembly and conducted ground testing.
  - Completed engine and infrared payload testing.
  - Demonstrated inter-vehicle communications, mission processing and execution capability.
  - Performed supersonic engine flight verification and seeker/advanced payload verification.
  - Conducted demonstration of subsonic vehicle interceptor and collaborative formation flying mission.
  - Conducted flight intercept demonstration against a representative target.
  - Continued to explore alternative mission concepts for low cost MALI airframes, including ground-launched variant of interceptor vehicle for use by land forces.

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- Orbital Express Space Operations Architecture. ($6.825 Million)
  - Continued the identification, definition and analysis of the requirements for on-orbit satellite servicing.
  - Continued to analyze the utility, cost effectiveness and life-cycle costs.
  - Continued redefinition of the Operational System Concept.
  - Continued nomination process of a baseline satellite-servicing mission.
  - Continued to define a servicing concept of operations.
  - Defined a draft, non-proprietary satellite-to-satellite interface standard.
  - Performed risk reduction research and development activities of critical items.
  - Completed initial demonstration test plan.
  - Conducted preliminary design review and developed request for proposals in preparation for Phase II.

- Quiet Supersonic Platform. ($19.860 Million)
  - Continued development of technologies for long-range supersonic aircraft having low sonic boom and noise signature, range augmentation through low vehicle drag and system weight reduction.
  - Developed conceptual designs for highly integrated supersonic long-range aircraft.

(U) <u>FY 2002 Plans:</u>

- Advanced Air Vehicle: Hummingbird Warrior. ($15.000 Million)
  - Fabricate and test low vibration rotor modifications for A160 air vehicle.
  - Continue ground and flight test of A160.
  - Integrate/demonstrate electro-optic/infrared surveillance payload on A160 vehicle.
  - Concept design of unmanned ground vehicle deployment system on A160 vehicle.
  - Perform conceptual design and trade studies of a rotorcraft variant of the unmanned combat air vehicles developed under this project, including study of technology risk reduction, architecture, survivability and command and control sensor development.

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- Orbital Express Space Operations Architecture. ($31.700 Million)
  - Complete Phase I.
  - Conduct Source Selection and initiate Phase II of the demonstration system.
  - Complete demonstration system detailed design including standard (non-proprietary) satellite-to-satellite electrical and mechanical interfaces.
  - Define objectives for micro-satellite operations in the Phase II on-orbit demonstration.
  - Develop key enabling technologies and continue risk reduction activities.
  - Initiate fabrication of demonstration system/subsystems.
  - Initiate auto guidance, navigation and control system and software design.

- Unmanned Combat Air Vehicle (UCAV). ($60.000 Million)
  - Complete conceptual layout design phase and begin detailed design/long lead procurement of a third air vehicle (X-45B), which incorporates integrated apertures and antennas, integrated weapons, distributed avionics, low observable (LO) treatments and exhaust, and increased functionality.
  - Conduct high-fidelity component radar cross-section analysis, define LO treatment suite, and initiate large-scale component test article design and fabrication.
  - Initiate development of an advanced electronic support measures subsystem, synthetic aperture radar, and satellite communication terminal tailored for the X-45B.
  - Complete design of a fully interoperable mission control system architecture incorporating multilevel security features in both hardware and software.
  - Complete conceptual layout design phase and begin detailed design/long lead procurement of the X-45B container and support equipment.

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- Naval Unmanned Combat Air Vehicle (UCAV-N). ($27.000 Million)
  - Conduct demonstrations of technologies, processes, and systems attributes to demonstrate the feasibility of UCAV operation from ships.
  - Conduct maritime network centric warfare.
  - Initiate detailed design of a demonstrator aircraft.

- Quiet Supersonic Platform. ($1.000 Million)
  - Perform validation of technologies for long-range supersonic aircraft having low noise signature.

- Satellite Protection and Warning (SPAWN). ($5.000 Million)
  - Define requirements for a micro (50 to 100 kg) satellites to provide enhanced situational awareness for national security satellites.
  - Multiple awards of Phase I concept definition efforts.
  - Identify candidate sensor technologies and characterization techniques, select approaches for further development.
  - Devise architectures and concept of operations; determine the feasibility and utility of these missions.
  - Perform risk reduction research and development activities of critical items.

- Space Battle Management Command, Control and Communications (SBMC^3). ($5.000 Million)
  - Define computing and communication interfaces with legacy systems.
  - Devise computing and communication architectures and concept of operations; determine effectiveness in high tempo scenario with modeling and simulation.
  - Identify candidate algorithms and technologies to mitigate high-risk areas, select approaches for further development.
  - Initiate the design, development, and integration of proof-of-principle algorithms and technologies.

- Deep View. ($5.000 Million)
  - Perform initial radar system design.
  - Perform analysis of transmitter technology alternatives.
  - Analyze antenna design requirements.

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- Space Technologies. ($4.000 Million)
  - Initiate feasibility studies; develop conceptual designs and figures of merit for morphing/shape control of space vehicles.
  - Develop multifunctional structure concepts for reducing weight, improving survivability and adaptively changing capability of space structures.
  - Initiate design for integrated hybrid power module and quantify performance improvements in powering radio frequency , microwave and optical system.

(U) <u>FY 2003 Plans:</u>

- Advanced Air Vehicle: Hummingbird Warrior. ($9.000 Million)
  - Continue flight tests of A160 air vehicles.
  - Fabricate forward pass mini control station for A160.
  - Demonstrate forward pass operations with Electro-Optic/Infrared (EO/IR) on A160.
  - Flight test low vibration four-blade rotor modifications for A160.
  - Develop advanced airframe helo modification for A160.
  - Investigate application of the optimum speed rotor (OSR) concept to tilt rotor aircraft, including preliminary design of an unmanned system.
  - Develop high-efficiency heavy fuel engine technologies.

- Unmanned Combat Air Vehicle (UCAV). ($60.000 Million)
  - Continue design and begin component fabrication of the X-45B air vehicle, mission control system and container.
  - Continue development of an advanced electronic support measures subsystem, synthetic aperture radar, and satellite communication terminal tailored for the X-45B.
  - Define the Block 4 system software requirements for integrating dynamic replanning/low observable auto-routing and multi-vehicle cooperative targeting decision aids into the air vehicle mission management system.

- Naval Unmanned Combat Air Vehicle (UCAV-N). ($25.000 Million)
  - Continue development and demonstration of technologies to operate from ships and unprepared areas ashore.

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- Complete detailed design and initiate construction of demonstrator aircraft.

- Quiet Supersonic Platform. ($15.000 Million)
  - Perform trade-studies and mission utility analysis.
  - Conduct integration experiments and demonstrations of enabling technologies.
  - Initiate preliminary system designs of highly integrated supersonic long-range aircraft.

- Unmanned Combat Armed Rotorcraft (UCAR). ($23.000 Million)
  - Complete Phase I and select up to two teams for Phase II development.
  - Develop UCAR preliminary design, risk management plan, and technology and system maturation plan.
  - Continue system trades, effectiveness, and affordability through modeling and simulation.
  - Develop sufficient system concept fidelity to validate program goals and objectives.

(U) <u>Other Program Funding Summary Cost:</u>

- Advanced Air Vehicle: Hummingbird Warrior:

	FY 2001	FY 2002	FY 2003
SOCOM	0.500	1.000	0.000

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- Unmanned Combat Air Vehicle (UCAV):

Air Force	24.800	21.100	58.000

- Naval Unmanned Combat Air Vehicle (UCAV-N):

Navy	1.500	15.000	25.000

(U) <u>Schedule Profile:</u>

Plan	Milestones
Advanced Air Vehicle (AAV):	
Apr 02	A160 Electro-Optic/Infrared payload first flight.
Jul 02	A160 Higher Harmonic Control Rotor system first flight.
Sep 02	Complete initial concept design and trades studies of rotorcraft variant of an unmanned combat air vehicle.
Jun 03	A160 Compound Helo Design Review.
Jun 03	A160 Flight with Forward Pass Ground Control Station.
Miniature Air-Launched Interceptor (MALI):	
Feb 02	Supersonic Intercept Free Flight demonstration.
Orbital Express Space Operations Architecture:	
Mar 02	Conduct Delta preliminary design review.
Jun 02	Conduct Critical Design Review.
Aug 02	Begin subsystem fabrication; complete system level simulator for integrated software testing.
Nov 02	Begin subsystem level environmental qualification testing; initiate fabrication of ASTRO and NextSat satellites.

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Unmanned Combat Air Vehicle (UCAV):

Mar 02	System B Interim Design Review.
Sep 02	System B mid-term Design Review.
Jan 03	Begin System B long lead fabrication.
Sep 03	System B Final Design Review.
Oct 03	Block 4 Software Requirements Review.

Naval Unmanned Combat Air Vehicle (UCAV-N):

Apr 02	Conduct 12 percent low speed wind tunnel test.
Sep 02	Conduct 12 percent high-speed wind tunnel test.
Sep 02	Complete Distributed Control, AWACS/JSTARS and laboratory demonstration.
Nov 02	Demonstration and evaluation of Human Systems Interface Devices (HSI) in laboratory and maritime environment.
Dec 02	Complete Radar cross section Signature demonstration complete.
Jul 03	Complete deck operations demonstration.
Jul 03	Complete mission control system Navy C4I infrastructure integration demonstration.
Oct 03	Contractor X and Y UCAV-N Demonstration System (UDS) construction complete.
Dec 03	Conduct Next Generation synthetic aperature radar technology flight demonstration.
Dec 03	Contractor Y final UDS ground tests complete.

Quiet Supersonic Platform (QSP):

Aug 02	Complete laminar flow control supersonic wind tunnel tests.
Sep 02	Complete advanced structures experiment.
Dec 02	Complete Mission Vehicle Concept Definition.
Jan 03	Complete Shaped Sonic Boom Demonstration and Analysis.
Sept 03	Complete Engine Rig 1 Testing.

Space Battle Management Command, Control and Communications (SBMC^3):

Jul 02	Complete interface definition documentation.
Nov 02	Select teams for spacecraft hardware and ground segment automation.

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Deep View:

May 02	Complete preliminary design review.
Jul 02	Select transmitter technology.
Mar 03	Complete transmitter performance analysis.

Satellite Protection and Warning (SPAWN):

Feb 02	Initiate mission analysis and architecture studies.
Jun 02	Release Phase I solicitation for Concept Definition and Design Studies.
Sep 02	Multiple Phase I awards to industry teams.

Unmanned Combat Armed Rotorcraft:

Apr 02	Initiate Phase 1 Study.
Sep 02	Initial System Architecture Definition.
Mar 03	System Requirements Review.
Dec 03	Preliminary Design Review.

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COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Space Programs and Technology ASP-02	0.000	0.000	114.000	237.556	330.865	369.594	510.460	Continuing	Continuing

(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, 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. Because of the increasing national importance of this area, and the expanded resource allocations devoted to it, a separate project, ASP-02, has been created. Ongoing space-related programs in Advanced Aerospace Systems (Project ASP-01), Tactical Technology (Project TT-06) and Sensors and Guidance Technology (Projects SGT-02 and 03) in addition to new efforts, are now funded in this newly created project.

(U) 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. An important element of the program is the enabling nature of such capability for new space missions and its potential to reduce space program costs through spacecraft life extension ("Pre Planned Product Improvement," or "P3I"), comparable to what is done today with aircraft. During Phase I (Concept Definition) the type of satellite servicing to be emulated in the on-orbit demonstration will be identified (to include the type of hardware upgrades and reconfiguration to be supported, and the techniques to be adopted in transferring hardware and fuel between spacecraft), and detailed designs will be developed for "industry standard," nonproprietary satellite-to-satellite mechanical and electrical interfaces enabling on-orbit hardware and fluid transfers. Concepts for auxiliary missions for a servicing spacecraft, such as supporting operations of micro-satellites, will also be developed. A preliminary system design will emerge in conjunction with developments in software and sensors necessary for autonomous space operations to assess the potential significant cost savings for space operations. In Phase II, detailed design of the on-orbit demonstration spacecraft (the service vehicle, the demonstration "target," or serviced satellite, and the depot for replacement hardware and fuel) will occur and the spacecraft will be fabricated, integrated, ground tested, and space-qualified. In FY 2005, the demonstration spacecraft will be launched. On-orbit, the Orbital Express

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spacecraft will repeatedly demonstrate the feasibility of autonomously upgrading, refueling and reconfiguring satellites. Following an initial 4-6 month demonstration, the Orbital Express demonstration system will be transitioned to a follow-on customer for additional test and evaluation. This program was previously funded in FY 2002 in Project ASP-01, Advanced Aerospace Systems.

(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 technology and large, light-weight optics 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. Advances in lightweight optics will reduce the size and weight of the telescope, providing fast slewing and further increasing search rates. This capability will enable ground-based detection of un-cued objects in space for purposes such as asteroid detection and other defense missions. In FY 2002, this program was funded in PE 0603762E, Project SGT-02, Aerospace Surveillance Technology.

(U) The Innovative Space-Based Radar Antenna Technology (ISAT) effort will build on the FY 2002 conceptual designs addressing the technical and economic feasibility of developing space-based radar antennas necessary for tactical-grade ground moving target indication performance from space using rigidized inflatable technologies – a potentially key enabling technology. During FY 2003, DARPA will develop two competing conceptual designs, including a detailed technical design and focused testing of key design components such as flexible transmit/receive modules, thin-film solar cells, and membrane designs. Additionally, DARPA will conduct ground-based risk reduction experiments demonstrating the accuracy of the constitutive models for deployment and control of rigidized inflatable structures. DARPA will also develop performance predictions on the selected designs as well as lifecycle cost models. In FY 2002, a series of studies to prepare for this activity was funded in PE 0603762E, Project SGT-03, Air Defense Initiative.

(U) The Satellite Protection and Warning (SPAWN) program will examine the use of microsatellites to provide enhanced situational awareness for U.S. space assets. Functions will include self-inspection, characterization, space environment monitoring, and diagnosis of spacecraft anomalies. A key element of this program will be the use of modular satellite architecture to enable rapid integration of multiple payload combinations in response to varying mission requirements. In Phase I, a range of satellite warning and protection functions will be analyzed and ranked in order of utility, such as situational awareness, self-inspection, and characterization. A preliminary system design will detail the number, types and configurations of sensors as well as the software required for characterization and assessment, which will generate status reports and anomaly alerts. A high degree of autonomous operation, with reporting only on significant events or requests from the ground, will be a key objective. In Phase II, detailed designs of the on-orbit demonstration spacecraft will occur and the spacecraft will be fabricated, ground tested, and

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space-qualified. Finally, in FY 2005, the SPAWN demonstration spacecraft will be launched and engaged in a series of on-orbit demonstrations. In FY 2002, this program was funded in Project ASP-01, Advanced Aerospace Systems.

(U) The Space Battle Management Command, Control and Communications ($SBMC^3$) program will develop computing and communications technologies that will enable space forces to dominate the battlespace through automated spacecraft tracking and control, fusion of space surveillance sensor information, and assured command and control of space assets. This program will provide algorithms that enable correlation and handoff of data between space sensors of widely different sensing modalities, locations, and reporting intervals. Protocols for information exchange within the space control architecture will be optimized. Information systems for highly automated space object tracking, identification, and activity assessment will be developed. The space battle management architecture will feature streamlined human interaction for more rapid action timelines and reduced error rates in an environment of ever increasing numbers of sensors being controlled and objects being tracked, while maintaining assured human control of space activities. In FY 2002, this program was funded in Project ASP-01, Advanced Aerospace Systems.

(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, faint objects at orbits ranging from low-earth orbit (LEO) to geo-stationary (GEO) 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 developments will focus on transmitters capable of providing the required power to image to GEO 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. In FY 2002, this program was funded in Project ASP-01, Advanced Aerospace Systems.

(U) The Space Vehicle Technologies (SVT) program will pursue advances in breakthrough technologies for space power, propulsion, maneuvering, navigation, communications and other spacecraft subsystems. Technologies will be selected that can provide revolutionary enhancements in space-based mission performance and/or dramatic reductions in space vehicle ownership costs. Projects involving technologies that support new missions, including on-orbit servicing, space surveillance, and defense of space assets, will also be undertaken. Integration of commercially available technologies into space hardware and software will be explored, and new techniques, processes, materials and software will be developed where required. Radical approaches to prelaunch test and space qualification will also be explored. The capabilities resulting from the SVT program will enable new military missions not previously viewed as practicable from space, as well as enabling current space missions to be conducted in a more efficient and survivable manner.

(U) The Advanced MEMS Technologies program seeks to demonstrate microelectromechanical systems (MEMS) based technologies for

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space based applications such as a miniature spacecraft capable of maneuvering outside a satellite to perform a number of functions including inspection of the mother craft or of nearby objects. Beyond the requirements for electrical powering, communications, guidance and imaging technology, these MEMS picosatellites would require propulsion systems based on MEMS thrusters and would possibly include MEMS structures for thermal control.

(U) The Responsive Access, Small Cargo, Affordable Launch (RASCAL) program will develop and demonstrate the capability to launch small (under 110 pounds) satellites and commodity payloads into low-Earth orbit on demand and for a total launch cost of $10,000 per pound or less. This capability will enable cost effective use of on-orbit replacement and re-supply. This capability will also provide a means for rapid launch of orbital assets for changing national security needs. While the payload cost goal is commensurate with current large payload launch systems, it is more than a factor of five less than current capabilities for dedicated launch of payloads of this small size. This program will utilize reusable aircraft technology for the first stage and will take advantage of low-cost hybrid advanced rocket fuel 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. In FY 2002, this program was funded in Project TT-06, Advanced Tactical Technology.

(U) The Tactical Optical Sensing (TOS) program will develop and demonstrate technology to give the battlefield commander both moving target indications over a wide area and high resolution imaging over a small area, using a single optical sensor. This combination of capabilities in a single system enables true tactical use of space-based optical sensors, allowing the U.S. to move quickly from a surveillance mode to a target tracking and identification mode. This program will develop foveating-imaging techniques that have a large field of view at coarse resolution combined with a narrow field of view at fine resolution. The program will also develop techniques for carrying out moving target identification with optical sensors. Along with these technology developments, a demonstration system will be designed, built and flown in 2007.

(U) The Low Cost Tactical Imager (LCTI) program will develop a space-based sensor to provide high-resolution, day/night Earth-imaging using extremely lightweight optics and a compact design capable of being launched on a Pegasus air launch booster. By meeting the payload constraints of the Pegasus booster, LCTI will provide the capability to launch covertly on demand - anywhere, anytime, into any orbit - to defeat camouflage, concealment and deception techniques. Weight reduction of the optical system is a key enabler of this concept; it will be achieved by using diffractive optics to reduce the weight of the primary by an order of magnitude, and the weight of the system by half. If successful, this will be the first-ever use of diffractive optics for a reconnaissance application, and it will require the largest Fresnel lens built to date.

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(U) The Tactical Pointing Determination of Imaging Spacecraft (TPDIS) program will develop relocatable space surveillance radar to provide near-real time pointing determination of imaging spacecraft to the warfighter. Today, theater commanders are warned of enemy imaging spacecraft overflights. However, there is no capability to determine where the spacecraft were tasked to collect imagery. TPDIS will develop an order of magnitude improvement in resolution and accuracy over the current state of the art to provide position and pointing information of space-based imagers. This capability will offer warfighters indication and warning of enemy observations of U.S. and allied forces.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2001 Accomplishments:</u>

- Not Applicable.

(U) <u>FY 2002 Plans:</u>

- Not Applicable.

(U) <u>FY 2003 Plans:</u>

- Orbital Express Space Operations Architecture. ($30.000 Million)
  - Initiate fabrication of Autonomous Space Transfer and Robotic Orbiter (ASTRO) and Next Generation Satellite (NEXTSat).
  - Continue auto guidance, navigation and control system and software design; initiate testing on system simulators.
  - Perform critical technology/subsystem tests on Orbital Express hardware.
  - Begin integration and ground testing of Orbital Express system/subsystems.

- Space Surveillance Telescope. ($6.000 Million)
  - Begin fabrication of telescope optics and mount.
  - Complete focal plan fabrication.

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- Innovative Space-Based Radar Antenna Technology (ISAT). ($11.000 Million)
  - Select two competitive architectures, based on FY 2002 conceptual designs.
  - Refine performance and cost models for each candidate design and associated technologies.
  - Perform focused risk-reduction experiments on key technologies associated with selected conceptual designs.
  - Carry out ground-based experiments to validate FY 2002 modeling and simulation of rigidized inflatable technologies.

- Satellite Protection and Warning (SPAWN). ($6.000 Million)
  - Conduct preliminary design review and develop Request for Proposals in preparation for Phase II.
  - Conduct Source Selection and initiate Phase II of the demonstration system.
  - Initiate fabrication of demonstration system/subsystems.

- Space Battle Management Command, Control and Communications (SBMC^3). ($3.000 Million)
  - Complete proof-of-principle algorithms.
  - Test performance of algorithms against simulated and recorded data.
  - Initiate development of system testbed.
  - Incorporate performance models for advanced sensors into architecture analysis.

- Deep View. ($4.000 Million)
  - Begin transmitter component design and transmitter performance analysis.
  - Complete radar system design.
  - Complete antenna control design.
  - Begin image processing software development.

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- Space Vehicle Technologies (SVT). ($2.000 Million)
  - Identify candidate technologies for high payoff space application; select approaches for further development.
  - Award Phase I Concept Definition studies.

- Advanced MicroElectroMechanical Systems (MEMS). ($6.000 Million)
  - Demonstrate MEMS based Joule-Thompson and other approaches to micro-fluidic techniques to realize micro-coolers for critical electronic components.

- Responsive Access, Small Cargo, Affordable Launch (RASCAL). ($25.000 Million)
  - Phase 1 down select/Phase II source selection.
  - Mission cycle testing of the first-stage reuseable launch vehicle propulsion in wind tunnel.
  - Establish Preliminary and Critical Design of full system.
  - Continue to refine performance and cost models.
  - Early Risk Reduction testing of subsystems.
  - Integration of low cost expendable rocket vehicle and common head steering stage design.

- Tactical Optical Sensing. ($7.000 Million)
  - Develop candidate designs for dual-mode, foveal imaging sensor.
  - Develop performance models for candidate designs.
  - Initiate foveated imaging and optical moving target indications risk reduction technology development.
  - Initiate conceptual designs of a space-based foveal imaging sensor.

- Low Cost Tactical Imager. ($8.000 Million)
  - Develop candidate designs for low-cost, light-weight imaging system.
  - Estimate performance for candidate designs
  - Initiate diffractive optics technology risk reduction efforts.

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- Tactical Pointing Determination of Imaging Spacecraft. ($6.000 Million)
  - Initiate development of W-band technology risk reduction testbed.
  - Begin design of relocatable surveillance radar.

(U) Other Program Funding Summary Cost:

	FY 2001	FY 2002	FY 2003
Orbital Express:			
UPN 721-40 NASA Marshall Space Flight Center	0.000	10.000	10.000

(U) Schedule Profile:

Plan	Milestones
Orbital Express Space Operations Architecture:	
Jan 03	Complete alpha version of flight software; begin testing on satellite software simulator.
May 03	Complete beta version of autonomous guidance, navigation and control software; begin testing in full motion simulation facility.
Sep 03	Begin payload integration testing into Autonomous Space Transfer and Robotic Orbiter (ASTRO) and Next Generation Satellite buses.
Space Surveillance:	
Jan 03	Focal plane tile fabrication and initial testing complete.
Sep 03	Telescope optics layout complete.
Innovative Space-Based Radar Antenna Technology (ISAT):	
Oct 02	Down-select Conceptual Designs.
Dec 02	Begin Key Component Risk-Reduction Experiments.
May 03	Demonstrate Controlled Deployment and Rigidization Process Verifying Constitutive Equations.
Aug 03	Preliminary Design Reviews.

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Sep 03 Final Technical Report on Preliminary Designs.

Satellite Protection and Warning (SPAWN):

Jun 03 Conduct Phase I final reviews.

Aug 03 Conduct Release solicitation for Phase II detailed design and fabrication.

Space Battle Management Command, Control and Communications (SBMC^3):

Nov 02 Select teams for spacecraft hardware and ground segment automation.

Jul 03 Complete proof-of-concept algorithm design.

Sept 03 Complete proof-of-concept algorithm testing.

Deep View:

Mar 03 Complete transmitter performance analysis.

Jun 03 Complete critical design review.

Space Vehicle Technologies (SVT):

Jan 03 Select teams for technology development projects.

Jun 03 Complete agreements with launch providers and technology demonstration bus programs for on-orbit testing of technologies.

Advanced MicroElectroMechanical Systems (MEMS).

Sep 03 Demonstrate MEMS based approaches to micro-fluidic techniques to realize micro-coolers for electronic components.

Responsive Access, Small Cargo, Affordable Launch (RASCAL):

Apr 03 Preliminary Design Review.

Jul 03 Critical Design Review.

Jul 03 Cost Model Feasibility Tool.

Oct 03 System Level Design.

Oct 03 Down select Phase I.

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Tactical Optical Sensing

Jan 03	Select teams for technology development efforts.
Aug 03	Complete conceptual system design.

Low Cost Tactical Imager

Jan 03	Select teams for technology development efforts.
Aug 03	Complete conceptual system design.

Tactical Pointing Determination of Imaging Spacecraft

Jan 03	Initiate risk reduction activity.
Aug 03	Complete preliminary system design.