RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, R-1 #16

COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	163.827	169.641	250.558	256.175	244.241	240.561	253.673	248.091
Naval Warfare Technology TT-03	20.340	25.345	28.857	24.813	14.971	14.656	14.643	14.628
Advanced Land Systems Technology TT-04	26.812	34.963	41.416	48.806	48.979	46.311	57.463	37.446
Advanced Tactical Technology TT-06	65.480	67.752	86.914	86.878	80.483	78.951	78.093	78.017
Aeronautics Technology TT-07	20.304	21.865	19.721	23.760	28.377	29.314	29.285	29.256
Advanced Logistics Technology TT-10	22.348	19.716	19.858	0.000	0.000	0.000	0.000	0.000
Joint Logistics ACTDs TT-11	8.543	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Network Centric Enabling Technology TT-13	0.000	0.000	53.792	71.918	71.431	71.329	74.189	88.744

(U) Mission Description:

(U) This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Aeronautics, Logistics and Network Centric Enabling technologies.

(U) The Naval Warfare Technology project is focusing on advanced enabling technologies for a broad range of naval requirements. The Friction Drag Reduction program will develop friction drag reduction technologies for surface ships and submersibles. The Hypersonics Flight Demonstration program will develop and demonstrate advanced technologies for hypersonic flight. The High Efficiency Distributed Lighting program will change the fundamental design for lighting systems, resulting in increased warship maintainability and survivability.

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(U) The Advanced Land Systems Technology project is developing technologies for enhancing the U.S. military's effectiveness and survivability in operations ranging from force-on-force conflict to military Operations-Other-Than-War. The Alternatives to Antipersonnel Landmines program will explore technologies to obviate the need for mines. The Close-In Sensing program will develop technologies to complement remote sensing assets. Networking Extreme Environments will address integration of ultra wide band communications and sensor systems. Lastly, the Simulated Isomer Energy Release program will develop techniques to extract and control the potent energies stored in nuclear isomers.

(U) The Advanced Tactical Technology project is exploring the application of compact and solid state lasers; high performance computational algorithms to enhance performance of radars, sensors, communications, and electronic warfare and target recognition and tracking systems; precision optics components for critical DoD applications; aerospace electronic warfare systems; high speed aerospace vehicle and enabling technology; and new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, and enabling technologies for advanced space systems. The Training Superiority program will create revolutionary new training techniques.

(U) The Aeronautics Technology project explores technologies to reduce costs associated with advanced aeronautical systems and provide revolutionary new capabilities for current and projected military mission requirements. This project funds development of micro adaptive flow control technologies; small-scale propulsion system concepts; innovative vertical take-off and landing concepts; long endurance unmanned air vehicle concepts; and advances for tilt-rotor aircraft. A new area to be investigated is in collision avoidance systems for micro air vehicles that are capable of flight in denied or congested areas.

(U) The Advanced Logistics Technology project investigates and demonstrates technologies that will make a fundamental difference in transportation and logistics. The program will define, develop and demonstrate fundamental enabling technologies that will permit forces and sustainment materiel to be deployed, tracked, refurbished, sustained and redeployed more effectively and efficiently. The project will also develop and demonstrate advanced military-grade measures for security, robustness and scalability to enable the wide-scale application of large-scale agent technology to U.S. military logistics and command and control domains operating in high-tempo conventional and information warfare environments.

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(U) The Joint Logistics project, composed of two Advanced Concept Technology Demonstrations (ACTD), transitioned joint logistics decision support tools (JDST) to the Service logistics communities.

(U) The Network Centric Enabling Technology project will build sensor, signal processing, detection, tracking and target identification technology for true network-centric tactical operations. Technologies developed in this project will enable localized, distributed and cross-platform collaborative processing so that networks of sensors can rapidly adapt to changing force mixes, communications connectivity and mission objectives. Operational benefits will be smaller forward deployment of image and signal analysts; consistent integration of target and environment information; and flexible operational tactics and procedures for finding evasive targets in difficult environments.

(U)	**Program Change Summary:** *(In Millions)*	**FY 2002**	**FY 2003**	**FY 2004**	**FY2005**
	Previous President's Budget	164.056	180.952	188.667	192.180
	Current President's Budget	163.827	169.641	250.558	256.175
	Total Adjustments	-0.229	-11.311	61.891	63.995
	Congressional program reductions	0.000	-17.311		
	Congressional increases	0.000	6.000		
	Reprogrammings	3.771	0.000		
	SBIR/STTR transfer	-4.000	0.000		

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(U) Change Summary Explanation:

FY 2002	Decrease reflects SBIR transfer and below threshold Reprogrammings.
FY 2003	Decrease reflects congressional program and undistributed reductions offset by an add to continue the Center of Excellence for Research in Ocean Sciences.
FY 2004-2005	Increases reflect initiation of several new solid-state laser programs and expansion of ongoing laser efforts in project TT-06, and creation of a new network-centric enabling technologies project in keeping with Agency emphasis in this critical area.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Naval Warfare Technology TT-03	20.340	25.345	28.857	24.813	14.971	14.656	14.643	14.628

(U) Mission Description:

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling technologies include concepts for expanding the envelope of operational naval capabilities.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Friction Drag Reduction	5.640	2.903	0.570	0.000

(U) The Friction Drag Reduction program is further developing friction drag reduction technologies investigated under PE 0601101E, Project MS-01, for surface ships and submersibles that can be practically implemented in the operational environment. The goal is the development of radical skin friction drag reduction sustained over time periods that are operationally relevant. This program will focus on two methods known to reduce friction drag: injection of polymers or microbubbles into the flow boundary layer. The program will address, by means of advanced computational and experimental techniques, the practical barriers to the implementation of polymer additives and microbubbles.

(U) This program will also examine the potential of Lorentz Force Turbulence Control (LFTC), an approach to reduce hydrodynamic drag by the generation of electromagnetic forces. Laboratory tests have demonstrated effective underwater drag reduction, but no energy efficient, repeatable method has ever been validated. LFTC offers the potential to achieve revolutionary hydrodynamic performance improvements in military systems by actively controlling drag, turbulence, and friction. Other drag reduction techniques that are discovered by these investigations will also be explored.

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(U) Program Plans:
- Perform drag reduction tests of LFTC tiles.
- Develop a sound theoretical understanding of the underlying mechanisms of friction drag reduction using first-principles codes and small-scale experiments.
- Develop a multi-scale modeling capability that allows for the incorporation of the physics learned at small scales into large-scale engineering codes for use as reliably predictive design tools.
- Conduct a near full-scale experiment to provide high-quality data at large scales in order to validate the models.

Nomenclature Title	FY 2002	FY 2003	FY 2004	FY 2005
Hypersonics Flight Demonstration (HyFly)	10.000	16.591	22.099	19.615

(U) The Hypersonics Flight Demonstration program (HyFly) will develop and demonstrate advanced technologies for hypersonic flight. Flight-testing will be initiated early in the program and progress from relatively simple and low-risk tests through the demonstration of an increasingly more difficult set of objectives. The ultimate goals of the program are to demonstrate a vehicle range of 600 nautical miles with a block speed of 4,400 feet per sec, maximum sustainable cruise speed in excess of Mach 6, and the ability to deploy a simulated or surrogate submunition. Technical challenges include the scramjet propulsion system, lightweight, high-temperature materials for both aerodynamic and propulsion structures, and guidance and control in the hypersonic flight regime. Recently demonstrated performance in ground testing of the dual combustion ram-jet engine coupled with advances in high temperature, lightweight aerospace materials are enabling technologies for this program. The program will pursue a dual approach. The core program will focus on development and demonstration of capabilities requisite for an operational weapon. A separate effort will be performed in parallel to demonstrate advanced propulsion technologies and develop low-cost test techniques. DARPA and the Navy established a joint program to pursue areas of the hypersonics program that would be relevant to maritime applications.

(U) Program Plans:
- Perform preliminary and detailed design efforts and supporting materials-structural demonstrations.
- Conduct freejet aero-propulsion testing of the heavyweight vehicle configuration.
- Perform ground test verification (static firing) of supersonic low altitude target boosters.

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- Perform advanced combustion systems proof of concept testing in gun-launched test range.
- Perform vehicle subsystems verification testing.
- Conduct ballistic and free-flight subscale testing of advanced engine technologies.
- Conduct sled test of simulated submunition deployment.
- Conduct flightweight vehicle environmental testing.
- Conduct flightweight vehicle freejet performance and durability testing.
- Conduct captive carry, drop, boost performance and boost separation flight tests.
- Conduct initial, low flight Mach (~Mach 4.0) flight-testing.
- Demonstrate Mach 6.0 cruise and extended range (600 nmi).

	FY 2002	FY 2003	FY 2004	FY 2005
High Efficiency Distributed Lighting (HEDLight)	0.000	0.000	6.188	5.198

(U) The High Efficiency Distributed Lighting (HEDLight) program seeks to fundamentally change the design for lighting systems on Navy platforms to increase warship survivability and maintainability. These goals will be accomplished by replacing the present form of electrical distribution and point-of-use light generation with centralized light generation and optical delivery to point-of-use. This allows the lighting system electrical circuitry and wiring to be concentrated, protected, and removed to the interior of the warship, and thereby removes a source of vulnerability from the outer envelope. Critical metrics that are necessary for the successful implementation of HEDLight are system efficiency, weight, and control of illumination pattern. The technical areas key to the success of the HEDLight program include: the development of compact high-efficiency full-spectrum light sources, high efficiency coupling optics, high efficiency integrated optical-fiber luminaires, and integrated illuminator engines that effectively combine source, coupling, and fiber-luminaire.

(U) Program Plans:

- Develop high efficiency small-extent full-spectrum light source.
- Develop high efficiency distributed lighting illuminator.
- Conduct system architecture designs and vulnerability analyses.
- Demonstrate a limited scale HEDLight system.

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	FY 2002	FY 2003	FY 2004	FY 2005
Center of Excellence for Research in Ocean Sciences (CEROS)	4.700	5.851	0.000	0.000

(U) The Center of Excellence for Research in Ocean Sciences (CEROS) encourages leading edge research and development in ocean sciences, by involving highly specialized small businesses with recognized expertise in ocean related research, and providing access to the ocean sciences expertise of the University of Hawaii. Major research areas of interest have included shallow water surveillance technologies, ocean environmental preservation, new ocean platform and ship concepts, ocean measurement instrumentation, and unique properties of the deep ocean environment.

(U) Program Plans:

- Select projects for funding, both new efforts and follow-on development to projects selected in previous years.
- Contract selected projects and monitor progress of ocean related technologies of high interest to the DoD.
- Transition appropriate products to military use.

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

Hypersonics Flight Demonstration	FY 2002	FY 2003	FY 2004	FY 2005
PE 0602114N, PE 0603114N, PE 0603123N, Navy, Office of Naval Research	10.000	20.000	20.000	15.000

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Land Systems Technology TT-04	26.812	34.963	41.416	48.806	48.979	46.311	57.463	37.446

(U) Mission Description:

(U) This project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from force-on-force conflict to military Operations-Other-Than-War. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire. This project consists of the following programs: Antipersonnel Landmines Alternatives (APLA); Collaborative Munitions, Close-In Sensing / Odortype Detection / Dynamic Optical Tags; Guided Projectiles, Networking Extreme Environments (NetEx); Enduring Freedom Reconstruction; and Simulated Isomer Energy Release (SIER).

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Antipersonnel Landmine Alternatives	10.281	2.000	0.000	0.000

(U) The Antipersonnel Landmine Alternative (APLA) program developed technologies to provide warfighters with enhanced capabilities that obviate the need for antipersonnel landmines (APLs). Technologies investigated included self-healing minefields that achieve protection of antitank mines from both dismounted and mounted breaches without the use of APLs, and tags with minimally-guided, air-guided or ground-guided munitions to detect, locate and rapidly engage dismounted infantry permitting the compression of critical timelines and distance constraints that limit the effectiveness of conventional indirect and direct fires. The self healing minefield technologies transitioned to the Army (Tank and Automotive Command; Picatinay Arsenal; PM Close Combat Systems) for inclusion in future countermobility concepts for the Objective Force. The technology is also transitioning internally to the Collaborative Munitions programs.

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(U) Program Plans:
- Integrated final self-healing minefield system concept.
- Built and field tested at least 50 mine prototypes.
- Evaluated collective behaviors for breaching in simple minefields.
- Developed warhead and control electronics constraints for reduction of mine size and expanded munition target set.
- Developed reduced size and shock hardened minefield network hardware to survive mine delivery.
- Evaluated and test mine delivery system for Objective Force applications.
- Transitioned self-healing minefield concept to Army.

	FY 2002	FY 2003	FY 2004	FY 2005
Collaborative Munitions	0.000	6.212	5.000	5.000

(U) Based on the promising results derived from the APLA program, the Collaborative Munitions program seeks to expand the functionality and lethality of munitions by enabling new ways for them to collectively accomplish difficult and time critical missions like that of the APLA program. This program will develop enabling technologies for weapons whose mission effectiveness is increased or enabled through collaborative understanding and processing of their environment. This program will adapt recent advances in communications, computers, ad-hoc networking, and propellants/explosives to demonstrate significant leaps in combat capability. These technologies will demonstrate the increased combat effectiveness and the reliability of distributed, collaborative processing and mission execution.

(U) Program Plans:
- Develop collaborative munitions communications protocols and systems concepts.
- Develop distributed sensor and processing suites.
- Integrate collaborative munitions.
- Develop warhead and control electronics for expanded target set lethality.
- Investigate potential mobility alternatives for a collaborative munitions based system.

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	FY 2002	FY 2003	FY 2004	FY 2005
Close-In Sensing / Odortype Detection / Dynamic Optical Tags	10.735	13.000	11.536	12.544

(U) The Close-In Sensing program developed technologies and platforms to complement national remote sensing assets. An emphasis was placed on close-in sensors that exploit various phenomenologies to make robust detection, classification, and identification of time-critical targets, hardened, hidden and highly protected targets and characterization of the local radio frequency environment. The technologies investigated considered new hardware and approaches to detect traditionally low signal-to-noise or concealed targets without placing people in harm's way and included infiltration and exfiltration technologies to incorporate sensor data reachback capability. Several candidate technologies were explored with funding from FY 2002 and prior. Based on those efforts, more focused efforts into Odortype Detection and Dynamic Optical Tags will begin in FY 2003.

(U) The objective of the Odortype Detection Program is to determine whether genetically-determined odortypes can be used to identify specific individuals, and if so to develop enabling technology for detecting and identifying specific individuals by such odortypes. The program leverages research that has demonstrated that the same set of genes that code for internal immune system self/non-self recognition in mice, the Major Histocompatibility Complex (MHC), also code for individual odortypes. Although experimental data for humans is far less quantitative, behavioral studies have yielded compelling results to suggest that such MHC-determined odor individuality can also be expected in humans. Recent experimental results with mice suggest that MHC-determined urinary odor is expressed in a mixture of volatile carboxylic acids occurring in relative concentrations that are characteristic of the odortype. This suggests the possibility of an exploitable chemosignal corresponding to an individual's genetically determined odortype. Accordingly, the program will design detectors that exploit this phenomenon by reliably detecting and identifying specific signatures of interest.

(U) Based on the technical successes and demonstrated operational relevance of DARPA's Optical Tags program (PE0603764E, Project LNW-02), the Dynamic Optical Tags seeks to create a new tagging, tracking, and location capability for US Forces. This program will develop an optical tagging and interrogation technology that will enable small environmentally robust, retro reflecting tags that can be read by both handheld and airborne sensors at significant ranges. These tags can be used for unique, non-radio frequency (RF) identification of items of interest and also will be capable of providing persistent two-way communications for both tactical and logistics operations.

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(U) Program Plans:

- Close-In Sensing.
  - Continued trade off studies in advanced technologies for use in data infiltration and exfiltration.
  - Continued development of active array technologies.
  - Explored multi-sensor architectures and waveforms.
  - Explored novel radio frequency exploitation concepts.
  - Investigated sensor reachback technologies.

- Odortype Detection.
  - Investigate exploitable, robust signatures corresponding to individual human odortypes.
  - Identify the chemical make-up of genetically determined human body odor.
  - Examine the chemistry and impact of non-genetic background signals.
  - Design high sensitivity detectors that are capable of identifying specific signatures.

- Dynamic Optical Tags.
  - Identify promising retro reflecting techniques.
  - Develop most promising retro reflecting techniques into tag design.
  - Develop handheld and airborne interrogation systems.
  - Integrate & test components in a fully functional configuration.

	FY 2002	FY 2003	FY 2004	FY 2005
Guided Projectiles	5.796	6.529	3.164	1.000

(U) The Guided Projectiles program is developing and demonstrating highly maneuverable gun-launched projectiles, launch system and fire control for point defense against highly maneuverable anti-ship cruise missiles, ground-to-air and ground-to-ground threats. The supersonic interceptors provide high rate, multiple engagement defense of critical tactical or strategic assets, including naval surface ships, airborne

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intelligence, surveillances, and reconnaissance platforms, and fixed radar/command, control and communications sites. Supersonic flight control for aggressively maneuvering medium caliber projectiles will be developed and integrated into advanced projectile designs to achieve lateral accelerations far exceeding those achieved by "course-correcting" projectiles.

(U) Program Plans:

- Develop, model and validate supersonic flight control technologies.
- Initiate system-level concepts and error budgets.
- Conduct preliminary development and evaluation of key subsystem technologies.
- Select one or more guidance and control system components and integrate them on projectiles of various sizes.
- Perform initial flight demonstrations and target acquisition demonstrations.
- Use virtual prototypes and simulations to determine the increase in effectiveness over "dumb" bullets; evaluate the logistic cost savings.
- Fabricate and test critical subsystems for projectile maneuvering, guidance and data transmission.
- Conduct detailed design and feasibility tests of key fire control, lethality, flight control and launch components.

	FY 2002	FY 2003	FY 2004	FY 2005
Networking Extreme Environments (NetEx)	0.000	7.222	12.100	10.262

(U) Based on the promising results derived from the Close-In Sensing program, the Networking in Extreme Environments (NetEx) program will create a wireless networking technology for the military user that enables robust connectivity in harsh environments and support its integration into new and emerging sensor and communication systems. This program will develop an improved physical layer for networked communications based on a family of new ultra wideband (UWB) devices. These devices will enable reliable and efficient operations in harsh environments by exploiting the unique properties of UWB systems that allow them to work in a dense multi-path environment and to function as both a sensor and communications device. The program will adapt new and emerging ad-hoc routing protocols and multiple access schemes to take advantage of the unique properties of UWB to communicate in harsh environments, to very accurately resolve range, and to act as a radar based sensor.

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(U) Program Plans:
- Characterize the effect of UWB system operation on military radio frequency receivers.
- Perform a series of electromagnetic interference tests of UWB systems against wide range of military radio frequency receivers.
- Characterize and verify UWB systems and channel properties through a series of hardware tests and system simulations.
- Identify the spectral masks and modes of operation of UWB systems that will not cause undesired operation of other devices.
- Develop an improved UWB physical layer (improvement of greater than 20dB in signal to interferer ratio, an increase of more than 20dB in receiver sensitivity or code gain, and an order of magnitude reduction in size and power).
- Develop ad-hoc networking and multiple access protocols to take advantage of the unique properties of UWB.
- Integrate UWB communications and sensors systems into an interoperating net.
- Conduct experiments on the integration of UWB into an operating network.

	FY 2002	FY 2003	FY 2004	FY 2005
Simulated Isomer Energy Release (SIER)	0.000	0.000	9.616	20.000

(U) Nuclear isomers, such as hafnium 178m2, store in the nucleus 10,000 times as much energy per gram as TNT. The goal of the Simulated Isomer Energy Release program is to develop a technique to control the release of this energy. It will develop a way to make these isomers in gram-size quantities. The program will demonstrate that as much energy can be released as is used to initiate the reaction (a breakeven experiment) and, by its conclusion, demonstrate a 50 pound bomb that has the explosive force of a 2,000 pound bomb. The SIER effort was initiated as an alternative energy program in PE0602712E, project MPT-01, but was subsequently moved to project TT-04 when its potential as an explosive was realized.

(U) Program Plans:
- Select an isomer that can be triggered with photons in the x-ray range that will release more than 50 times the energy input and possesses an identifiable and feasible chain reaction.
- Design and fabricate a magnet for enrichment experiments.
- Demonstrate isomer producibility in the quantity and purity needed for a breakeven experiment; an enrichment process producing more then 90 percent purity material; and a breakeven experiment design with performance margins.

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– Demonstrate materials production scalable to military significant quantities, a successful breakeven experiment, and resolution of safety and environmental questions.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Tactical Technology TT-06	65.480	67.752	86.914	86.878	80.483	78.951	78.093	78.017

(U) Mission Description:

(U) This project focuses on three broad technology areas: (a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, holographic laser sensors, communications, and high-power laser applications; (b) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; (c) enabling technologies for advanced aerospace systems and emerging payload delivery concepts. Additionally, this project will develop new tactical systems for enhanced air vehicle survivability, precision optics, electronic warfare, advanced air breathing weapons and training superiority systems.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
High Power Fiber Lasers	3.115	6.135	11.787	11.769

(U) The High Power Fiber Lasers program will develop and demonstrate single mode fiber lasers with output powers of nearly one kilowatt from a single aperture. Tens of kilowatts output power and capability to scale to greater than hundreds of kilowatts output power and beyond will be demonstrated through coherent combining of the output power from multiple fiber lasers. High power fiber lasers will provide a quantum leap in defense capabilities by simplifying the logistic train and providing a deep magazine, limited only by electric power, in a compact footprint. For theater/area defense and self-protection of combat platforms, they will provide speed of light engagement and flexible response against cruise missiles, reconnaissance unmanned air vehicles (UAVs), and rockets.

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(U) Program Plans:
- Demonstrate greater than 100-watt output power from large mode-field area fibers.
- Demonstrate 1 kw single mode output power from coherently combining the out-power from greater than ten fiber lasers.
- Demonstrate tens of kilowatt output power and capability to scale to greater than hundreds of kilowatts output power.

	FY 2002	FY 2003	FY 2004	FY 2005
High Powered Femto Second Laser Diodes	7.475	6.443	2.726	0.000

(U) The development of high power, reliable semiconductor laser diodes with tunable femtosecond pulse widths and highly scalable power levels, represents a technological advance of great potential utility to the Department of Defense. The successful demonstration of a compact, efficient, and powerful laser diode could lead to incredible advances in micromachining, communications, ultra-short pulse spectroscopy, light detection and ranging (lidar) and directed energy applications with performance benefits with respect to its size and efficiency.

(U) Program Plans:
- Model and evaluate concepts for ultra-short pulse, high irradiance laser diodes and select mode locked grating coupled surface emitting laser diodes (GCSEL) and semiconductor optical amplification using chirped pulse amplification and compression.
- Develop series of GCSEL-based ultra-short pulse, ultra-high power lasers culminating in a 1 milliJoule/200 femtosecond per pulse laser with a 10 kHz repetition rate. This represents a seven order of magnitude jump in the performance of semiconducting laser diodes.
- Demonstrate ability of femtosecond laser to micromachine complex Defense parts.

	FY 2002	FY 2003	FY 2004	FY 2005
High Average Power Solid State Lasers	0.000	1.000	5.000	5.000

(U) The High Average Power Solid-State Laser program will develop and demonstrate a small volume, all-electric laser requiring no chemicals or having no disposables that will produce greater than 100kW of average power. It will operate at about 1060 nanometers in

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wavelength, have a beam divergence that exceeds the minimum possible by less than 50 percent, and has an electrical efficiency of greater than 50 percent.

(U) Program Plans:

- Demonstrate achievement of 4 kW of average power with a beam divergence smaller than 1.5 times that limited by diffraction.
- Demonstrate diodes pumps that are 65 percent efficient in producing light from electricity.
- Demonstrate a system level design of a new cooling technique the will possess less than one tenth the weight, volume and coolant flow rate as conventional coolers.
- Demonstrate achievement of 20kW of average power with a beam divergence smaller than 1.5 times that limited by diffraction.
- Demonstrate diode pumps that are 85 percent efficient.
- Demonstrate laser materials that will produce three times less heat than current materials.
- Demonstrate a coating technique that will produce coatings with ten times less absorption than current materials.
- Demonstrate 60 kW of average power and with a beam divergence that is smaller than 1.5 times that limited by diffraction.
- Demonstrate an integrated, anchored computer code that predicts successful generation of 100kW.

	FY 2002	FY 2003	FY 2004	FY 2005
High Energy Liquid Laser Area Defense System (HELLADS)	0.500	5.211	10.804	20.841

(U) The goal of the High Energy Liquid Laser Area Defense System (HELLADS) program is to develop a high-energy laser weapon system (~150 kW) with an order of magnitude reduction in weight compared to existing laser systems. With a weight goal of less than 5 kg/kW, HELLADS will enable high-energy lasers (HELs) to be integrated onto tactical aircraft and UAVs and will significantly increase engagement ranges compared to ground-based systems. This program initiative will investigate and validate a revolutionary laser design that enables a lightweight HEL weapon system. HELLADS will design, fabricate and test a prototype laser. Once laser performance parameters have been demonstrated, a subscale HEL laser will then be fabricated and tested. Once key weapon system parameters have been demonstrated, a full-scale 150 kW HEL weapon system will be fabricated and demonstrated. Finally, the 150 kW HEL will be integrated into a surrogate aircraft and key performance parameters will be demonstrated.

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(U) Program Plans:
- Conduct key technology demonstrations of resonator stability, laser gain, and system thermal performance.
- Develop and test a 1-kW sub-scale HEL system.
- Complete detailed design and initiate construction of 150 kW laser weapon system.
- Demonstrate performance of a 150 kW HEL system in a ground test.
- Integrate HEL system into surrogate aircraft.
- Demonstrate performance of a 150 kW HEL system in captive flight test.

	FY 2002	FY 2003	FY 2004	FY 2005
Laser Star	2.231	3.340	8.476	5.885

(U) The Laser Star program will investigate technologies and techniques for improving laser guide star generation for adaptive optics atmospheric compensation of laser propagation. Current technology makes use of either stratospheric Rayleigh backscatter or mesospheric sodium resonance scattering. These techniques have been utilized to successfully demonstrate strategies for wavefront compensation, but suffer from practical restrictions limiting operational utility. Rayleigh guide stars can be effectively generated to altitudes of 15 – 20 km, beyond which decreasing air densities reduce the backscatter to the point where unrealistic laser powers are required for useful return signal. The altitude is insufficient to provide full atmospheric sampling and suffers from focus anisoplanatism. Sodium resonance scattering is available to 90 km, which is an essentially complete atmosphere sample, but the return is monochromatic and cannot provide information about turbulence-induced absolute tilt. Furthermore, the brightness is insufficient for wave front sensing over large apertures.

(U) Program Plans:
- Complete concept design.
- Develop experiment design and procure long lead items.
- Conduct experiment.
- Analyze data and integrate with atmospheric compensation programs.

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	FY 2002	FY 2003	FY 2004	FY 2005
Chemical Oxygen Iodine Laser Solid Gas Generator (COILSOGG)	2.000	0.495	0.000	0.000

(U) Phase 1 of the Chemical Oxygen Iodine Laser Solid-Gas Generator (COIL-SOGG) program is developing and demonstrating the feasibility of using a solid-gas chemical reaction to generate singlet-delta oxygen. The program will also explore other similar reactions and reactor designs to determine the most efficient chemical constituents.

(U) Program Plans:

- Design and construct bench-level COIL SOGG device.
- Measure singlet-delta oxygen yield, water number density, chloride utilization versus time, species quenching, and other parameters critical to feasible utilization in a weapon-class COIL.
- Perform a system study to examine the potential performance benefits of COIL-SOGG for the Air Borne Laser.

	FY 2002	FY 2003	FY 2004	FY 2005
Compact Lasers for Coherent Communications, Imaging and Targeting	6.634	4.518	7.324	7.599

(U) The Coherent Communications, Imaging and Targeting (CCIT) program will provide powerful new capabilities for secure communication up-links (multi-giga bits per second), and aberration free 3-dimensional imaging and targeting at very long ranges (greater than 1,000 kilometers). Innovative design concepts for MEMs based SLMs, which provide a quantum leap in wavefront control, and system integration of photonics and high-speed electronics will also be explored. The CCIT program will develop a scalable prototype system and perform basic demonstrations of communications and imaging up to 10 km through a highly aberrating environment, as well as full scale end-to-end demonstrations from ground to mountain-top platform. The CCIT system will address the critical need for high-data-rate communications and imaging from land, sea and airborne platforms to space.

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(U) Program Plans:

- Develop 256x256 element spatial light modulators and integrated electronics, with pixel flatness of one fiftieth of a wavelength, 98 percent fill factor, eight bits of phase resolution and ten micro-second response time.
- Develop and demonstrate 1024x1024 element spatial light modulator with integrated electronics.
- Develop prototype system with high-speed parallel electronics and demonstrate horizontal slantpath communication links and aberration-free coherent imaging with ranges up to 10 kilometers.

	FY 2002	FY 2003	FY 2004	FY 2005
High Performance Algorithm Development/Virtual Electromagnetic Test Range	9.328	11.392	8.579	7.000

(U) The High Performance Algorithm Development and Advanced Mathematics for Microstructural Process Control programs identify, develop and demonstrate new mathematical paradigms enabling maximum performance at minimum cost in a variety of DoD systems applications. They will look for opportunities to aggressively leverage the power of mathematical representations in order to effectively exploit the power of large-scale computational resources as they apply to specific problems of interest. The products are typically advanced algorithms and design methodologies. DARPA is pursuing the development of well-conditioned fast algorithms and strategies for the exploitation of high-dimensional data (i.e., data with a high number of degrees of freedom) in order to deal with a variety of complex military problems including virtual integrated prototyping of advanced material and device processing, digital representation and analysis of terrain and other geospatial data, efficient high fidelity scattering computations of radar scattering for predictive design and exploitation of radar cross sections, and efficient automatic mapping and optimization of signal processing kernels onto advanced Departmental computational hardware architectures.

(U) Program Plans:

- Demonstrate efficient, accurate predictive algorithms for electromagnetic scattering from objects composed of inhomogeneous and anisotropic materials and including cracks, cavities gaps and thin edges; apply these codes to the accurate computation of radar cross section (RCS).
- Demonstrate efficient scattering codes capable of accurate computation of RCS for cruise-missile-sized vehicles with realistic material boundary conditions and full complexity components including high fidelity computational electromagnetic modeling capability for multisensor apertures and arrays.

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- Determine tractable Bio Regulatory Network component subnetworks, manipulation techniques, measurement methodology, and develop reduced-order mathematical models for cell-based simulation of engineered constructs, such as analog circuits and control loops that could be used to optimize an engineering design in analog circuitry or other relevant design domain.
- Develop innovative designs for analog systems with digital feedback control to extract high-level digital information from analog sources, such as digitized speech phonemes from acoustical signals or matched filter values from radar signals.
- Explore innovative mathematical representations of digital data and systems that provide improved efficiency and robustness against error and uncertainty compared to current representations.
- Design and implement unified digital representations for map, terrain, and other geospatial data that will support highly efficient storage, query, and registration of geographical information from disparate sources.
- Demonstrate localized representations for high-altitude gravity data that provide the precision of current representations with ten percent of current storage requirements.
- Develop and test algorithms designed to exploit the presence of multiple scattering and clutter to enable increased communication bandwidth at fixed power in acoustic and wireless applications.
- Develop and test algorithms to exploit the presence of multiple scattering and clutter (e.g., foliage canopy) to enable imaging in the presence of multiple scattering and dispersion to enable image formation for acoustic, synthetic aperture radar, and active electro-optic sensors.

	FY 2002	FY 2003	FY 2004	FY 2005
Integrated Sensing and Processing	5.203	8.500	7.500	6.000

(U) The Integrated Sensing and Processing program will open a new paradigm for application of mathematics to the design and operation of sensor/exploitation systems and networks of such systems by developing and applying novel optimization methodologies for integrating sensing, processing, and information exploitation functionality in sensor systems. This program will create tools enabling the design and global optimization of advanced sensor system architectures comprising fully interdependent networks of functional elements, each of which can fill the roles and functions of several distinct subsystems in current generation sensor systems. Payoffs will include improved performance with reduced complexity of hardware and software in a wide variety of systems, including agile adaptive arrays for missile seekers, unmanned air vehicles, and

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space-borne sensors; novel waveforms, adaptive waveform design and processing for object identification in dispersive and turbulent media; and novel approaches to multiplexed hyperspectral chemical/biochemical sensing systems.

(U) Program Plans:

- Develop and demonstrate new mathematical approaches to adaptive optimal control of tunable, mode-switchable, and configurable sensor systems/networks in which detection, estimation, classification, and tracking requirements determine sensing system operating parameters.
- Investigate extraction of high-level information directly from analog signals as part of the analog-to-digital conversion process, allowing joint optimization of traditionally separate sensing and processing functions.
- Develop real-time waveform design and scheduling strategies for ambiguity reduction and clutter mitigation in pulse diversity radar systems.
- Develop and demonstrate multiplex sensing, feature extraction and three-dimensional imaging capability in passive interferometric sensors.
- Develop and demonstrate spatio-spectral feature extraction and four-dimensional (three spatial, one spectral) reconstructions in passive interferometric sensors.
- Demonstrate feasibility of designs for quadrature thinning of two-dimensional conformal arrays that exhibit the same or better beam patterns than conventional arrays using fewer transmit/receive modules.
- Develop information-theoretic metrics relating detection, estimation, classification, and tracking requirements to waveform structure in active sensing systems and use these metrics to devise new classes of mathematically optimal waveforms.

	FY 2002	FY 2003	FY 2004	FY 2005
Mission Specific Processing (MSP)	8.383	9.431	3.398	0.000

(U) The Mission Specific Processing (MSP) program extends Adaptive Computing Systems (ACS) technologies to support the design of highly optimized embedded processors that are required in the most severely constrained DoD applications. ACS developed new approaches to the design of computer hardware that incorporated dynamic configuration capabilities. The technology developed by this program will facilitate high performance processing in future space based and miniature aero systems (unmanned air vehicles and missiles) that require extremely high

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processing throughput while consuming the minimum possible volume, weight and power. The focus is on providing a ten-fold gain in power-performance over current standard cell ASIC designs by incorporating full-custom design optimizations into standard libraries.

(U) Program Plans:

- Conduct simulation and benchmarking of initial custom design techniques in the context of mission specific signal processing requirements.
- Identify opportunities for ten-fold improvement in operations per second per watt per square centimeter for key Digital Signal Processor functions; verify via appropriate simulation methods.
- Develop detailed system architecture of wideband adaptive radar/electronic intelligence-/seeker receiver enabled by MSP method.
- Begin development of a wideband adaptive radar receiver based on MSP custom cell libraries and modules.
- Select the target semi-custom, full scale chips for development.
- Complete development of a wideband adaptive receiver system.
- Demonstrate a ten-fold performance improvement in custom radar signal processing chips.
- Develop a test and demonstration plan for a fully functional adaptive radar processor.
- Complete library of key Digital Signal Processing function kernels and supporting tool augmentations.
- Complete development of adaptive processor for seeker-receiver.
- Complete design of innovative application specific integrated circuit (ASIC) architecture for Electronic Intelligence processor.
- Transition MSP kernel library/methods so that they are available to industry for design and fabrication of chips required by DoD applications.
- Conduct first pass evaluation of semi-custom, full scale chips in the adaptive receiver testbed.
- Demonstrate full scale ASIC development using MSP architectures and techniques focusing on MSP design methodologies that reduce design time requirements as compared with full custom.
- Complete a test system representative of a real application in that real or synthetic data is processed at the rate required by the selected application.
- Complete a demonstration that addresses system level issues and quantifies the increased performance relative to semi-custom ASIC designs, field programmable gate arrays (FPGAs), and commercial off the shelf (COTS) processors.

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	FY 2002	FY 2003	FY 2004	FY 2005
Water Rocket	3.041	3.355	1.203	0.000

(U) The Water Rocket program will support research and development of a robust concept for space power and propulsion supported by water as a replenishable propellant and fuel. Water is an inexpensive and easily handled propellant. The program will develop and demonstrate thrusters that use water or its constituents, hydrogen and oxygen. High power thrusters will be developed for rapid maneuvering and high specific impulse thrusters will be developed for greater economy in use of the water propellant. A regenerative fuel cell system, enabled by emerging new technologies, will be developed and demonstrated. The regenerative fuel cell will serve two purposes: 1) it will convert the water to hydrogen and oxygen for use in thrusters, and 2) it will generate electricity while converting some of the hydrogen and oxygen back to water, thereby replacing the heavy batteries routinely used in satellites to supply electric power during nighttime. As a result of this program, future spacecraft will be more easily refueled for extensive maneuvering and changes of orbit to accomplish advanced missions.

(U) Program Plans:

- Perform critical technology demonstrations and analysis of the system design for the regenerative fuel cell and other developmental components, including thrusters.
- Design, fabricate, and test a brassboard regenerative fuel cell system demonstrating performance and endurance.

	FY 2002	FY 2003	FY 2004	FY 2005
Responsive Access, Small Cargo, Affordable Launch (RASCAL)	17.320	0.000	0.000	0.000

(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 reusable launch vehicle and a second stage expendable rocket vehicle. 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

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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. In FY 2003, this program is funded from Project ASP-02, Space Programs and Technology.

(U) Program Plans:

- Select Mass Injection Pre-Compressor Cooled (MIPCC) technology development team.
- Determine feasibility of concept.
- Determine preferred system concept for downselect.
- Develop Draft Contractor Life Cycle Cost Model (CLCC).
- Prototype MIPCC manifold – engine testing.
- Select Phase II preferred system concept(s).
- Establish Preliminary and Critical Design of full system.
- Conduct mission cycle testing of the first-stage reusable launch vehicle propulsion in direct connect wind tunnel.
- Conduct early Risk Reduction testing of subsystems: wind tunnel, scaled static fires, Guidance, Navigation and Control (GN&C) simulation, material coupon testing, Radar Cross-Section (RCS) firing.
- Select Phase III team(s) for preferred flight test program.
- Conduct static fire of potential new rocket motor designs.
- 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.

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	FY 2002	FY 2003	FY 2004	FY 2005
Superconducting Generator	0.000	1.000	2.500	2.500

(U) The Superconducting Generator program will develop a 5 MW superconducting generator for application to airborne directed energy, which requires a very light-weight generator. To achieve light weight, the generator will utilize high-temperature superconducting wire, which is now becoming available in adequate lengths for an acceptable price. The goal is to demonstrate a turbine, generator, and supporting power conditioning and cryogenic cooling in a system of less than 1000 kg. The Air Force is developing plans to build and demonstrate the complete airborne directed energy system using the superconducting generator.

(U) Program Plans:
- Design generator in detail and build and test critical components.
- Build and demonstrate the generator with an available turbine.

	FY 2002	FY 2003	FY 2004	FY 2005
Varuna	0.000	0.000	4.008	7.830

(U) The goal of the Varuna program is to develop and demonstrate ultra miniature audio and video recording, tracking and locating systems. In the first phase of the program, an audio recorder system will be developed with the capability of storing at least two hours of audio data, with a goal of six hours. The second phase of the program focuses on adding video to the audio recorder and developing a tracking and locating device. The video system will be able to collect and store at least two hours of video data at a 0.5 Hz frame rate, with a goal of six hours, in addition to the quantity of audio data recorded in Phase 1 of the program. The tracking and locating device will be capable of operating anywhere in the world, including inside buildings, under heavy canopy, in urban canyons and in vehicles. The size goal for these devices will be accomplished primarily by thinning silicon integrated circuit chips, dielectric interface layers and passive components and assembling these thinned subassemblies into a small package. The tracking and locating device will require the development of a miniature antenna as well as advanced communications techniques to enable operation in deep fade environments.

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(U) Program Plans:
- Build an audio system breadboard.
- Complete Phase I audio system development.
- Conduct Source Selection for Phase II.
- Build a video system breadboard.
- Complete video system with fixed optics.
- Incorporate adaptive optics in the video system.
- Build audio/video system in final size.
- Demonstrate tracking and locating concept.
- Build tracking and locating breadboard.
- Complete tracking and locating device in final size.

	FY 2002	FY 2003	FY 2004	FY 2005
Training Superiority	0.000	6.000	12.921	12.325

(U) The Training Superiority program will change the paradigm for the way the military trains by creating new approaches to increase technical and physical competence as a result of revolutionary new training techniques developed in this program. Passive teaching approaches, including web-based training, will not succeed in instilling the skills and knowledge needed in the new land-battlefield, with higher demands on fewer soldiers, including the need to control and interact with highly technical unmanned systems. These new training approaches will include elements of human-tutor interactions and the emotional involvement of computer games coupled with the fidelity and feedback of Combat Training Center learning. In addition, these new training approaches will be linked into existing Service and Joint training systems to form a self-sustaining architecture, allowing continuous on-demand training anywhere at anytime.

(U) Program Plans:
- Develop, demonstrate and validate a continuously available, on-demand combat training system for all forces in the skills needed for successful performance across a comprehensive range of military operations, engagements and come-as-you-are wars.

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- Develop, validate, demonstrate and deliver to military last-meter training systems that are focused on specific areas of performance requirements (e.g., "seabag sized" air mission trainer, tactical language instruction).
- Create an overarching training architecture populated with scalable multiple last-meter training systems that will allow any unit or individual, active, reserve, or civilian, to enter the virtual training world at any time, from any place, using existing hardware, and receive training tailored to specific individual training needs.

	FY 2002	FY 2003	FY 2004	FY 2005
Language and Speech Exploitation of Resources Advanced Concept Technology Demo	0.250	0.932	0.688	0.129

(U) DARPA's Babylon program is providing research and development to support speech translation on small platforms for military-critical languages. The speech integrated product team of the Language and Speech Exploitation of Resources Advanced Concept Technology Demonstration (ACTD) seeks to transition this technology into ACTD-supported military utility assessments (MUAs). One of the competitively selected DARPA developers has developed and perfected a technology for information extraction that will be applied for the first time to speech translation. This technology will allow flexible and accurate translation of varying utterances without requiring recognition and translation of every word in the utterance.

(U) Program Plans:

- Refine capabilities of the two-way translator for testing in MUAs.
- Develop translator in Arabic dialect – a language for which substantial speech data have been collected and annotated as required to develop speech recognizers.
- Integrate component technologies including:
  - -- Speech recognition in English and Arabic.
  - -- Speech playback in Arabic and English.
  - -- Information extraction and translation from Arabic to English.
- Port translator to a second critical language (e.g., Vietnamese, Thai), for which little annotated speech data is now available.
- Install translator on small, readily available platforms (e.g., laptops, handhelds).

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- Test and evaluate in the service labs supporting the ACTD.
- Provide translators to the ACTD for MUAs.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Aeronautics Technology TT-07	20.304	21.865	19.721	23.760	28.377	29.314	29.285	29.256

(U) Mission Description:

(U) Aeronautics Technology efforts will address high payoff opportunities that dramatically reduce costs associated with advanced aeronautical systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Micro Adaptive Flow Control (MAFC)	8.887	7.117	6.920	6.920

(U) Micro Adaptive Flow Control (MAFC) technologies enable control of large-scale aerodynamic flows using small-scale actuators. MAFC technologies combine adaptive control strategies with advanced actuator concepts like micro-scale synthetic jets, microelectromechanical systems (MEMS)-based microactuators, pulsed-blowing, combustion actuators and smart structures to cause the delay, or prevention, of fluid flow separation. MAFC technologies will be explored for applications such as download and drag reduction for air vehicles, adaptive lift-on-demand for agile missiles and uninhabited tactical aircraft, supersonic boundary layer control, lightweight gas turbine engines, and low-drag, non-intrusive methods to aerodynamically steer projectiles for extended range and precision.

(U) The program is entering Phase III where two or three of the most promising applications will be evaluated in full-scale adaptive flow control demonstrations. The first Phase III demonstration, scheduled to take place in May 2003, will be a demonstration of flow control, using synthetic jets, to reduce the download on the XV-15 aircraft by at least 10 percent. This amount of download reduction would enable a payload increase of 1000 lbs on the V-22. Leading technical challenges include the development of robust actuators with the required force, displacement, and bandwidth for real applications, and the integration of novel actuators including combustion gas actuation, phased plasma actuators, and synthetic jets with MEMS-based flow sensors and embedded, adaptive controllers. These challenges require the development of new approaches

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for power conditioning and distribution, and the definition and implementation of control system architectures, including embedded sensing, data communication, processing and actuation.

(U) Program Plans:
- Executed Phase II, high speed, closed loop technology demonstrations.
- Identify Phase III follow on efforts from the projects with the most promising Phase II results.
- Configure and optimize the XV-15 aircraft and actuation system to prepare for download reduction testing.
- Perform XV-15 download reduction testing at Bell Helicopter Textron to demonstrate adaptive flow control on full-scale applications.
- Configure and execute Phase III full-scale technology demonstrations.

	FY 2002	FY 2003	FY 2004	FY 2005
Small Scale Propulsion Systems (SSPS)	6.691	4.656	0.469	0.000

(U) Concepts for a new, small scale class of propulsion systems will be developed in the size range from 0.5 cm to 7.0 cm in diameter, with thrust levels from 10g to 10kg. They will enable future development of a new generation of very small weapons and military platforms including micro air vehicles, unmanned combat air vehicles, missiles and space launch vehicles. Radical new capabilities to be explored range from shirt-button-sized gas turbine and rocket engines to 7 cm scale gas turbine and pulse detonation engines. Engines may be explored at larger scale to prove feasibility. Examples of new mission capabilities may include delivery of very small (200g) satellites to low earth orbit, extended range small-scale precision munitions, and lightweight, long endurance miniature reconnaissance vehicles. These small-scale munitions would complement emerging unmanned vehicle systems and greatly increase mission capabilities by simultaneously increasing loadout, range and precision.

(U) Program Plans:
- Demonstrate a liquid-fueled micro-rocket with turbopumps operating with 1.5kg thrust.
- Achieve diesel fuel operation of a novel crankless internal combustion engine.
- Demonstrate a valve-less, high-frequency pulse detonation engine.
- Demonstrate a 20:1 thrust to weight ratio on a small diesel-fueled turbojet engine.

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	FY 2002	FY 2003	FY 2004	FY 2005
Canard Rotor/Wing (CRW)	2.026	0.000	0.000	0.000

(U) The services have a need for affordable, survivable, air vehicles to support dispersed units in littoral and urban areas. The Canard Rotor/Wing (CRW) aircraft offers the potential for a high-speed rapid response capability from a vertical take-off and landing (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. In FY 2003, this program is funded in PE 0603285E, Project ASP-01, Advanced Aerospace Systems.

(U) Program Plans:
- Completed ground testing and conducted demonstrator flight tests at Yuma Proving Grounds.
- Completed design and development of follow-on manned and unmanned vehicles.

	FY 2002	FY 2003	FY 2004	FY 2005
Long Endurance Hydrogen Powered Unmanned Air Vehicle	2.700	3.880	4.262	6.160

(U) DARPA is continuing its investment in innovative, long endurance unmanned air vehicle (UAV) technology. The military application of such vehicles is the provision of reliable, tactically controlled intelligence, surveillance and reconnaissance and communications equivalent to low earth orbit satellites. To achieve endurance on the order of two weeks, at operationally significant altitudes (60,000+ ft), with 250+ lb payloads it is necessary to develop airframes with very high strength and low structural weight. It is also necessary to develop high efficiency propulsion systems with sufficient peak power to provide station keeping in periodic high winds. Recent advances in high strength, all composite airframes, hydrogen fuel cell technology and high strength, composite, hydrogen dewars suggest that such a vehicle design is realizable.

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(U) Program Plans:
- Conduct design trades and critical item demonstrations on structural and propulsion concepts.
- Prepare preliminary design of 14 day, 250+ lb payload, 60,000 ft cruise UAV.
- Continue testing of critical items and subsystems related to structure, propulsion, flight control and payload.
- Complete conceptual design of aircraft.

	FY 2002	FY 2003	FY 2004	FY 2005
Unmanned Tilt Rotor (UTR)	0.000	2.490	3.159	5.305

(U) There is an increasing need for airlift capability to support quick response operations. To address this, the Unmanned Tilt-Rotor (UTR) program will exploit a new and revolutionary advance in tilt rotor aircraft, using the patented Optimum Speed Rotor (OSR) technology, demonstrated in the UAV helicopter p. Scaling studies indicate that a very large tilt-rotor aircraft employing large diameter variable rpm OSR props/rotors for high efficiency hover and flight would achieve high transit speed (greater than 350 kts) and extremely long ranges. This technology will give rise to a VTOL cargo lifter capable of deploying directly from CONUS to combat and also have the capability for intra-theater transport of maneuver brigades. DARPA has determined that a rapid and cost-effective means to demonstrate the critical technologies in this vehicle is with a subscale UTR aircraft. The program will develop this advanced concept with a 8,500 lb UTR vehicle.

(U) Program Plans:
- Initiate preliminary design with focus on prop rotor, wing, tail and power train subsystems.
- Perform risk reduction experiments and concept development analysis and simulation.

	FY 2002	FY 2003	FY 2004	FY 2005
Organic Air Vehicles (OAV) in the Trees	0.000	3.722	4.911	5.375

(U) Organic Air Vehicles (OAV) in the Trees will develop and test collision avoidance systems for micro air vehicle (MAV) systems, capable of reconnaissance and surveillance, to support flight in denied/congested areas. Initial capabilities (in Phase I) will be for field and forest operations with dispersed and distributed targets at low altitudes appropriate to “under the canopy” conditions. During Phase II, surveillance and

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reconnaissance applications for urban and city operations and then building interior operations including stairwells will be added and evaluated. Phase III will demonstrate and test 3D flight within confined and highly irregular air space such as tunnels, airshafts, and caves. This program will assess and rationalize the quality, precision and detail of five sensor options for reconnaissance and surveillance for OAV flight under the canopy applications: 1) mono-vision in visible light and/or infrared (IR), 2) stereo-vision in visible light and/or IR, 3) LIDAR (laser imaging distance and ranging), 4) micro radar systems, and 5) active and passive acoustic sensor arrays on the vehicle.

(U) Program Plans:

- Initiate Phase I activities, including evaluation of sensors and design collision avoidance systems.
- Perform system preliminary and critical design reviews.
- Fabricate and integrate sensor suites.
- Initiate flight testing:
  - Under the canopy (in the trees)
  - Urban terrain (in and around buildings)
  - Highly irregular air space (tunnels, airshafts, caves)

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Logistics Technology TT-10	22.348	19.716	19.858	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) The objective of the Advanced Logistics Technology project is to revolutionize the way the DoD plans, executes, monitors, and dynamically replans logistics support across the entire spectrum of operational environments from day-to-day routine peacetime operations to disaster relief, non-combatant evacuation, peacekeeping, peacemaking, and minor and major contingencies. The project involves the creation of a set of hardened functional information systems technologies and supporting business processes that support the development of military logistics applications that are survivable and secure even in the most hostile, chaotic wartime environments.

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

	FY 2002	FY 2003	FY 2004	FY 2005
UltraLog	22.348	19.716	19.858	0.000

(U) The UltraLog program provides technologies to make our highly distributed military information systems inherently survivable even in the most hostile kinetic and cyber warfare environments. UltraLog's technical approach is to use intelligent agent technology to enhance the robustness, stability and security of the core military logistics data and information processing, thereby resulting in a resilient and trustworthy logistics system that can reliably adapt under harsh, dynamic conditions. UltraLog's strategy is to pursue survivability research breakthroughs in agent technology, and then validate them through integration into a large-scale logistics information system testbed that supports highly detailed component-level and systems-level assessment. The technologies developed under UltraLog ensure that future information systems, particularly logistics systems that interact with non-military vendors, 1) can survive directed cyber attack (technologies include: dynamic Public Key Infrastructure management, information rovers, pedigree, dynamic policy-based control, and random routing); 2) can sustain operations in a chaotic kinetic warfare environment (technologies include: non-local persistence, distributed consistency checking, agent-based fault tolerance, and dynamic communications-aware redundancy and adaptation); and 3) can deal with the complexity of multiple current operations ranging in

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tempo from peacetime training to major regional contingencies with proper management of plans and priorities (technologies include: assured convergence, adaptive configuration, variable fidelity processes and reactive plan-space management). In FY 2002, UltraLog developed an initial suite of agent system survivability technologies, and individually assessed them in a testbed logistics systems context.

(U) Program Plans:

- Develop, integrate and evaluate technologies providing dynamic information security and agent system survivability for sustained wartime logistics operations in a harsh kinetic and information warfare environment.
- Establish and support a fully instrumented and configurable test environment, which includes the ability to experimentally generate infrastructure and communications failures, chaotic requirement flows and selected security breaches.
- Conduct rigorous assessments by external, independent evaluation teams to verify and validate the concept of operations and technical architecture of the approach, as well as establish specific system component survivability and overall logistics systems functionality under stress.
- Create a prototype of 1000-agent logistics information system that is capable of operating under direct adversary cyber attack and absorbing significant infrastructure loss, with acceptable capabilities and performance degradation during high-tempo military operations.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Network Centric Enabling Technology TT-13	0.000	0.000	53.792	71.918	71.431	71.329	74.189	88.744

(U) Mission Description:

(U) The objective of the Network Centric Enabling Technology project is to provide a technical foundation for building mission applications explicitly tailored to network-centric system architectures. Mission applications include signal processing, detection, tracking, identification, planning, and control functions. These applications will integrate: (1) external sensors that provide data on targets and their mission contexts, (2) external platforms, both air and surface, that deliver sensors and munitions to designated areas, and (3) external communications networks that provide connectivity between computing nodes located on the platforms, at field command centers, and within the homeland. The mission applications themselves share data to form consistent operating pictures of the battlespace, tailored to the needs of commanders at each node. They also negotiate plans for future operations based on mission needs presented at each node. To maintain focus on operationally relevant problems, the technical goals will be posed and evaluated in the context of robotic forces – collections of a few dozen robotic platforms whose operations must be coordinated to achieve specified mission goals.

(U) Technologies developed in this project will enable localized, distributed and cross-platform collaborative processing so that networks of sensors can rapidly adapt to changing force mixes, communications connectivity and mission objectives. Technologies will be demonstrated and evaluated both in the laboratory, and in hardware-in-the-loop demonstrations using both stationary and autonomous mobile platforms. Operational benefits will be smaller forward deployment of image and signal analysts; consistent integration of target and environment information; and flexible operational tactics and procedures for finding evasive targets in difficult environments.

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(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Mixed Initiative Control of Automa-Teams (MICA)	0.000	0.000	17.570	15.570

(U) The Mixed Initiative Control of Automa-teams (MICA) program is developing algorithms, software, modeling and simulation capabilities to perform multi-level planning, assessment and control of distributed, autonomous combat forces. MICA will provide a commander with the operational and mission planning tools to select optimal team composition, to perform dynamic tasking and re-tasking of teams, and to generate cooperative routes for autonomous Unmanned Air Vehicles in stressful operational missions, especially suppression of enemy air defenses. Mixed initiative control will develop collaborative strategies and tactics for these teams under the supervision of a single human operator, with adjustable autonomy determining the degree of human authority desired or required during task execution. Through the exploitation of control science metrics for stability, performance and robustness, these teams of cooperative, autonomous vehicles such as Unmanned Combat Air Vehicles will accommodate uncertainty in both the operating environment and feedback information, as well as address the presence of an intelligent adversary and fixed/mobile threats in the battlespace. In FY 2004 and FY 2005, these hierarchical battle management and control methodologies will be demonstrated, with humans-in-the-loop, initially in a simulation and subsequently in a hardware demonstration. This program was previously funded in PE 0602301E, Project ST-19 in FY 2002 and FY 2003 ($10.5 million and $16.7 million, respectively).

(U) Program Plans:

- Apply and refine algorithms and software to assign autonomous combat vehicles to task-oriented teams, and mission-derived subtasks to each combat vehicle in a team.
- Apply and refine algorithms and software to generate event schedules and collaborative routes for each combat vehicle in a team, with collision avoidance and self-reorganization in the presence of fixed/mobile threats.
- Apply and refine algorithms and software supporting dialog between human commanders/operators and semi-autonomous entities to communicate recommended courses of action, appropriate feedback information and decision tuning parameters.
- Deploy a third and fourth phase open experimental simulation environment stressing multi-team coordination and cooperative planning for sensor and weapon platforms against difficult and time sensitive ground targets with responsive operator control and intervention.

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- Demonstrate cooperative management of 2-5 teams of 5-10 platforms and one operator with team self-organization in the presence of over 250 active fixed and mobile threats.
- Validate and verify algorithms and control software in a reduced scale hardware environment with a single team of air vehicles performing cooperative activities.

	FY 2002	FY 2003	FY 2004	FY 2005
Network Embedded Software	0.000	0.000	17.570	15.260

(U) The Networked Embedded Systems Technology (NEST) program provides robust coordination and synthesis services subject to extreme timing, power, and resource constraints for networked embedded systems. Future microelectromechanical systems will offer novel solutions for fine-grain distributed estimation and control applications. These applications contain at least 100,000 simple computing nodes. NEST will provide reusable code-base, tools, and reference applications to dramatically simplify the software development task in a wide range of future weapon systems. If not done, application developers will need to constantly reinvent theoretically involved and computationally complex solutions for embedded subsystem coordination and synthesis, which cannot provide guarantees for predictable behavior of large-scale networked systems. This program was previously funded in PE 0602301E, Project ST-19 in FY 2002 and FY 2003.

(U) Program Plans:

- Develop security services for authentication, data integrity and tolerance against jamming, blocking and other forms of intrusion in embedded networks.
- Demonstrate composable self-stabilizing protocols for hybrid systems.
- Develop and demonstrate domain-independent, transition-aware solver framework.
- Demonstrate end-to-end synthesis of coordination package based on specific application characteristics.
- Evaluate coordination and synthesis services on 100,000 node system.
- Demonstrate capabilities in urban and special operations targeting field tests.

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	FY 2002	FY 2003	FY 2004	FY 2005
RoboScout	0.000	0.000	5.000	9.800

(U) The RoboScout program will focus on low cost, mobile sensors for close-in reconnaissance. The primary goal of the program is developing sensors to be mounted on fixed wing, rotary wing or ground platforms to acquire data necessary to detect, recognize and track vehicles and dismounts in complex, cluttered environments; constructing and validating statistical models of these target signatures and environments. In addition, the program will explore a variety of candidate sensors, including low-cost light-weight radio/radar systems based on software-defined radio technology with programmable functions and waveforms for networking, GMTI, SAR, high resolution rotorcraft radar, innovative active optical sensors (spectral, polarimetric, vibrometric) intentional and unintentional RF emissions receivers, acoustic/seismic and EO/IR imagers. The program will evaluate the contribution of and derive performance goals for individual sensor types to detection, tracking, and identification of targets. Sensors will be designed, prototyped, and tested to verify performance levels. A robust, flexible suite of sensors for small vehicles will be developed that can provide a commander with awareness of threats, own forces and noncombatants over a variety of weather, illumination and operational conditions. Mounted on autonomous air and ground vehicles, this will provide flexible and adaptive coverage without putting U.S. forces into dangerous or difficult situations.

(U) Program Plans:

- Characterize signatures of emerging and expected threats, and clutter generated by the environments in which they may be found.
- Model the performance of different sensors against those signatures.
- Analyze the performance of different combinations of sensors in representative mission environments.
- Derive performance goals for sensors.
- Construct candidate sensor designs with different performance, weight, and power levels.
- Simulate selected designs against high-fidelity environmental models.
- Build prototype implementations of selected sensors.
- Perform field tests of prototypes to verify performance predictions and to assess robustness against unmodeled physical effects.
- Develop techniques to perform coordinated exploitation across networks of video sensors.
- Demonstrate the ability to track individual moving vehicles and people across large areas for extended periods of time.

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– Perform motion pattern analysis on traffic flows in urban environments to detect, predict, and explain potentially hostile acts against US forces and facilities.

	FY 2002	FY 2003	FY 2004	FY 2005
Organic Sensor Exploitation Networks	0.000	0.000	4.000	9.800

(U) The Organic Sensor Exploitation Network (OSEN) program will develop rapid, highly autonomous techniques for sensor exploitation in support of autonomous sensor networks in ground warfare. It will develop technology to: 1) permit on-board exploitation of sensor data from remotely deployed sensor nodes; 2) support correlation of information developed across different platforms; 3) detect, track and identify targets in the field of view of a platform; 4) cue other sensors to acquire a target; and 5) hand off targets to other platforms as targets move through different sensor fields of view. System studies will evaluate the relative value of different sensor mixes against low-flying aircraft, ground vehicles, dismounted infantry and irregular forces. Sensor candidates will include electro-optical, infrared, radar, passive RF, acoustic, seismic, and magnetics. Sensors may be fixed or mounted on mobile platforms. Communications connectivity will be variable, with models to predict changes caused by line-of-sight occlusions. The goal of the OSEN program is to provide network-enabling technology for processes currently performed at centralized ground stations and analysis centers, so that processing can be moved closer to the sensor. This reduces the need for expensive communications back to a central site, and provides robustness to unexpected loss of platforms, communications disruptions and target behavior.

(U) Program Plans:

– Define representative sensor mixes and operational scenarios.
– Perform analytical trade studies to generate representative sensor network components and tactics.
– Develop a functional architecture for each network node that can be adapted to the particular sensors and communications devices present at that node.
– Prototype candidate algorithms for each function (search, detect, track, identify, correlation, hand off) based on alternative technologies.
– Evaluate candidate algorithms in a synthetic environment to calibrate and verify performance models.
– Insert selected algorithms into a hardware-in-the-loop testbed to demonstrate practical utility and to verify system performance.

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	FY 2002	FY 2003	FY 2004	FY 2005
Eyes-On System	0.000	0.000	3.500	7.300

(U) The goal of the Eyes-On (EyO) program is to develop a capability to enter and survey a target area using an air launched micro-Unmanned Air Vehicle to deliver just-in-time visual confirmation of target ID, establish conditions for collateral damage avoidance in engagement zone, and perform real-time bomb damage assessment (BDA). Very high resolution COTS electro-optical/infrared sensors integrated into low-signature sensing platform will be used to achieve visual confirmation of target to human-in-the-loop by going close-in and under-weather. Pre-surveying the engagement zone for collateral damage avoidance will support go/no-go attack decisions under restrictive rules of engagement. A limited loitering capability will then allow Eyes-On (EyO) to support real time bomb damage assessment (BDA) post-attack. Key attributes of the EyO concept is the utilization of line of sight RF communications and local command and control system technologies to deliver exquisite just-in-time visual confirmation into the fighter cockpit. In addition, the program will develop and demonstrate the capability to support discrimination between non-combatants and combatants. Support of long-range weapon delivery will also be demonstrated, using the forward deployed, loitering micro-robotic forward area controller to monitor the target area throughout the weapons fly out duration. The program includes adaptation of existing sensor and platform designs with fabrication of prototype small UAVs in prototype quantities. Each prototype will consist of the air vehicle, a sensor package, flight control system, and data link back to the launch platform. Effectiveness of the prototypes will be demonstrated in flight tests at the end of the program.

(U) Program Plans:

- Define system architecture to include command and control requirements.
- Analyze tradeoffs between sensing performance, target location and referencing designs, data rates, and smart processing aboard the small UAV.
- Develop candidate designs at different points of these tradeoff curves.
- Simulate each design over a suite of missions, and select the one that provides the best overall actionable-ID capability.
- Brassboard and install the selected sensor, signal processing, flight control and data link software on a recoverable test platform.
- Construct and test complete prototype systems.

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	FY 2002	FY 2003	FY 2004	FY 2005
Urban Robotic Surveillance	0.000	0.000	0.000	7.350

(U) The Urban Robotic Surveillance System (URS) program will develop new mobile sensor systems, including both long-endurance ground and short-endurance air platforms, for operation in constrained urban environments. To achieve this, it will explore a mix of sensor technologies (EO/IR video, active optics, radar, acoustic, magnetic, chemical and RF direction finding) in environments characterized by complex multipath propagation, limited lines of sight and frequent obscuration. The program will select platforms and design sensor networks to operate in urban exterior, urban underground and urban indoor environments. Communications repeaters and routers will be included to maintain adequate terrestrial connectivity to all platforms and provide for autonomous operation if those communications are interrupted. In addition, it will include a resupply of fuel or power to forward-deployed platforms. The program will demonstrate and deliver a complete prototype robotic squad, operable by a small command staff, providing integrated, task-focused urban surveillance to augment or replace dismounted infantry in dangerous operations. Capability will be demonstrated in field tests at military activities in urban terrain sites with missions that include route clearing, flank protection, tunnel clearing, scout and peacekeeping operations in urban environments.

(U) Program Plans:

- Select a baseline set of sensors, data links and platforms.
- Design a flexible physical and logical architecture for a baseline URS system, with tasks and functions derived from standard urban reconnaissance operations plans.
- Construct a software testbed where candidate system components can be exercised in a synthetic urban battlespace.
- Develop alternative sensor models and algorithms (signal processing, object detection, object recognition, mapping, correlation, tracking, route generation and communications management).
- Compare alternatives in the synthetic testbed, and select combinations that offer the most robust and effective performance.
- Build a hardware testbed incorporating selected component sensors and algorithms.
- Exercise test platforms in a series of increasingly difficult mission/environment combinations and improve sensors or algorithms that limit performance.

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	FY 2002	FY 2003	FY 2004	FY 2005
Adaptive Reflexive Middleware Systems	0.000	0.000	6.152	6.838

(U) The Adaptive and Reflective Middleware Systems (ARMS) program focuses on the Total Ship Computing Environment (TSCE) that is used in the DD(X) Future Surface Combatant Family of Ships and associated network-centric DoD systems. The TSCE will be a fully integrated open system computing and information architecture that executes all tasks and mission applications optimized at the platform level, rather than the sub-system level, thus breaking down the traditional C4ISR, Combat Systems, and Ship Control System boundaries. The TSCE is a mission-critical distributed real-time, and embedded system where (1) different levels of service are possible and desirable under different conditions and costs and (2) the levels of service in one dimension must be coordinated with and/or traded off against the levels of service in other dimensions to achieve the intended overall result, even in the face of battle damage or heavy workloads. The autonomous behavior of TSCE systems requires the middleware components and frameworks to adapt robustly to quantifiable changes in environmental conditions. In ARMS, middleware will be responsible for coordinating the exchange of information efficiently, predictably, scalably, dependably and securely between remote entities by using advanced Quality of Service (QoS) capabilities of the underlying network and endsystems. ARMS was previously funded in PE 0602302E, Project AE-01.

(U) Program Plans:

- Define and prototype adaptive protocols, algorithms, patterns, and tools that can enforce security policies to enhance and support secure global resource allocation, scheduling, and control, and can ensure stability and dependability across multi-level feedback loops in the network-centric TSCE.
- Develop robust meta-programming policies and mechanisms based on standard middleware and demonstrate that the results assure the dynamic flexibility and QoS of the second DDX TSCE baseline.
- Define and prototype reflective techniques for synthesizing optimized distributed, real-time, and embedded middleware; develop languages, algorithms, and tools to configure customizable—yet standards-compliant—TSCE middleware and applications.
- Develop robust adaptive protocols, algorithms, patterns, and tools based on standard middleware and demonstrate that they can enforce the security policies to enhance and support secure global resource allocation, scheduling, and control for the third DDX TSCE baseline.

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- Develop and demonstrate robust reflective techniques for synthesizing optimized standards-based middleware and applying it to the fourth DDX TSCE baseline.
- Develop and capture design expertise in the form of pattern languages that formalizes the successful techniques and constraints associated with building, generating, and validating QoS-enabled middleware frameworks and protocol/service components for the DDX TSCE baselines.
- Demonstrate mature, standards-based middleware technologies that can transition with moderate to low risk to the DD(X) Surface Combatant Family of Ships and associated DoD combat systems.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	340.446	434.426	465.544	461.043	457.485	481.035	470.154	474.052
Materials Processing Technology MPT-01	162.434	134.744	133.312	135.478	140.495	162.006	158.139	158.959
Microelectronic Device Technologies MPT-02	106.678	121.993	163.776	179.073	196.340	209.592	214.399	217.572
Cryogenic Electronics MPT-06	7.823	4.149	4.911	9.808	14.678	16.611	19.523	19.504
Beyond Silicon MPT-08	63.511	88.459	78.871	47.826	19.570	14.657	0.000	0.000
Biologically Based Materials and Devices MPT-09	0.000	85.081	84.674	88.858	86.402	78.169	78.093	78.017

(U) Mission Description:

(U) This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technologies related to those materials, electronics, and biological systems that make possible a wide range of new military capabilities.

(U) The major goal of the Materials Processing Technology project is to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of