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COST (In Millions)	FY 2003	FY2004	FY2005	FY 2006	FY 2007	FY 2008	FY 2009
Total Program Element (PE) Cost	168.826	247.405	339.175	354.525	351.751	368.253	370.404
Naval Warfare Technology TT-03	28.746	47.613	46.813	24.971	24.656	30.643	30.628
Advanced Land Systems Technology TT-04	34.910	40.028	69.397	97.979	97.311	100.463	88.246
Advanced Tactical Technology TT-06	64.030	90.703	112.287	116.767	119.141	133.673	133.530
Aeronautics Technology TT-07	21.739	16.229	41.760	46.377	39.314	29.285	29.256
Advanced Logistics Technology TT-10	19.401	19.662	15.000	0.000	0.000	0.000	0.000
Network Centric Enabling Technology TT-13	0.000	33.170	53.918	68.431	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.

(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. Networking Extreme Environments will address integration of ultra wide band communications and sensor systems. The Novel Sensors for Force Protection program is developing technologies to protect U.S. warfighters such as an imaging array system that can identify bodies inside of buildings and technology capable of stand-off detection of explosive compounds. The Simulated Isomer Energy Release program will develop techniques to extract and control the

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potent energies stored in nuclear isomers. The Dynamic Optical Tags program will develop new tagging, tracking and location capabilities for U.S. forces. Lastly, the Guided Projectiles program will develop highly maneuverable gun-launched projectiles for defense against ground and air threats.

(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, 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; new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, and enabling technologies for advanced space systems; and a Training Superiority program that 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; and small-scale propulsion system concepts. New areas to be investigated are reusable hypersonic vehicles novel helicopter blade designs that reduce acoustic signature and small, low cost high endurance UAV's capable of destroying most enemy UAV's.

(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.

(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.

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

	FY 2003	FY 2004	FY2005
Previous President's Budget	169.641	250.558	256.175
Current President's Budget	168.826	247.405	339.175
Total Adjustments	-0.815	-3.153	83.000
Congressional program reductions	0.000	-10.153	
Congressional increases	0.000	7.000	
Reprogrammings	0.000	0.000	
SBIR/STTR transfer	-0.815	0.000	

(U) Change Summary Explanation:

FY 2003	Decrease reflects SBIR transfer.
FY 2004	Decrease reflects congressional program reductions for Roboscout, Odortype Detection and undistributed reductions offset by an add to continue funding for the Center of Excellence for Research in Ocean Sciences.
FY 2005	Increase reflects additional funding in the following projects: TT-03 for the Friction Drag Reduction program; TT-04 for additional programs for anti-sniper efforts, compact military engines and urban sensors; TT-06 for new advanced mathematics/algorithm development, laser techniques and advanced training systems; and TT-07 for Reusable Hypersonics.

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Naval Warfare Technology TT-03	28.746	47.613	46.813	24.971	24.656	30.643	30.628

(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 such as drag reduction, hypersonic missiles, logistically friendly distributed lighting systems and ship self defense techniques. Studies under this project examine methods of actively detecting, tracking, and containing submarines from manned, unmanned, surface, air, and underwater vessels, or a combination of such platforms, as well as more passive methods of sensing and recognizing changes in the marine environment.

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

	FY 2003	FY 2004	FY 2005
Friction Drag Reduction	6.063	7.295	5.260

(U) The Friction Drag Reduction program is developing friction drag reduction technologies for surface ships and submersibles in the operational environment. The program will focus on methods known to reduce friction drag, such as injection of polymers, injection of microbubbles into the flow boundary layer, and the insertion of large air cavities over traditionally wetted surfaces. The goal is radical skin friction drag reduction sustained over operationally-relevant time periods. The program will address, by means of advanced computational and experimental techniques, the practical barriers to the implementation of polymer additives and microbubbles. This capability would allow dramatic decreases in fuel usage, increases in payload fraction and substantial enhancements in vehicle range and endurance and could lead to increased vessel speed.

(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

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military systems by actively controlling drag, turbulence, and friction. Other drag reduction techniques that are discovered by these investigations will also be explored; both for their friction reduction and for potential ship self defense capabilities.

(U) As a result of studying typical electrical layouts and distribution grids in Navy ships under the Lorentz Force Turbulence Control (LFTC) effort, an alternative application of electricity based technology has been initiated. FY 2004 and subsequent fiscal funding for this effort, now entitled the Electric Curtain program, is budgeted in a separate line in this project.

(U) Program Plans:

- Performed drag reduction tests of LFTC tiles.
- Developed 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 will incorporate the physics learned at small scales into large-scale engineering codes for use as reliably predictive design tools.
- Finalize buoyancy test vehicle design and efficiency.
- Develop a preliminary test plan for full-scale buoyancy test vehicle experiment.
- Conduct a full-scale buoyancy test vehicle experiment to provide high-quality data at large scales in order to validate the models.
- Conduct large-scale experiments to provide high-quality data at large scales in order to validate the predictive design tools.
- Develop an air cavity design tool that calculates a hull form for specified pressure distributions.
- Perform modeling trade-off analysis to determine optimal hull forms supporting air cavity formation at design speed.
- Conduct tests to determine drag reduction achieved.

	FY 2003	FY 2004	FY 2005
Surface Warfare Automated Shiphandling (SWASH)	0.000	0.000	5.400

(U) The Surface Warfare Automated Shiphandling (SWASH) program will develop and demonstrate technologies to increase survivability and operational effectiveness of small and medium naval surface vessels in rough seas. Currently, vessels are at the mercy of ocean waves, and when waves become sufficiently large, damage and capsizing will occur. SWASH will enable safe operations in an expanded sea state envelope.

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SWASH combines detailed sensing and wave prediction of the local sea surface with improved understanding of vessel dynamics in a control system that provides optimum course and speed to the vessel's rudder and engines. SWASH offers the potential to reduce injuries to crew and passengers as well as damage to vessels caused by high waves. In addition, SWASH is an enabling technology for unmanned surface vessels (USVs), which will be a component of the modules for the Navy's new Littoral Combat Ships (LCS). SWASH will increase the survivability and operability of USVs in rough seas, and can provide inputs to the LCS steering system to make USV launch and recovery faster and safer. Medium manned vessels, such as LCS, DD(X), and current classes, will benefit from the more detailed knowledge of wave fields that will be developed in the SWASH program. Sophisticated steering strategies can reduce damage to the vessels caused by high waves, and improve human performance by reducing vessel motions.

(U) Program Plans:
- Refine prediction capability for ocean wave fields.
- Improve models of small craft dynamics in high sea states.
- Develop control algorithms for wave avoidance.
- Test control schemes in "virtual ocean" environment and scale model tests, followed by at-sea testing.

	FY 2003	FY 2004	FY 2005
Hypersonics Flight Demonstration (HyFly)	16.991	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

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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.
- 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 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 2003	FY 2004	FY 2005
High Efficiency Distributed Lighting (HEDLight)	0.000	6.188	6.700

(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. Current lighting systems use electrical distribution and the generation of light at the point-of-use. HEDLight remote source lighting will use centralized light generation and optically transport the light to the point-of-use. This allows the lighting system electrical circuitry and wiring to be concentrated, protected, and removed to the interior of the warship, thereby removing 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 the 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 luminaries, and integrated illuminator engines that effectively combine the light source, the optical coupler, and fiber-luminaire.

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(U) As a result of studying typical electrical layouts and distribution grids in Navy ships under this effort, an alternative application of electricity based technology has been developed and will be funded under the Electric Curtain program which is budgeted in a separate line in this project.

(U) Program Plans:
- Develop high efficiency full-spectrum light sources.
- Develop high efficiency optical coupling mechanisms.
- Develop high efficiency fiber-luminaries for distributed light transport.
- Develop an integrated high efficiency distributed lighting illuminator.
- Demonstrate a limited scale HEDLight system.

	FY 2003	FY 2004	FY 2005
Center of Excellence for Research in Ocean Sciences (CEROS)	5.692	7.000	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.
- Contract selected projects and monitored progress of ocean related technologies of high interest to the DoD.
- Transitioned appropriate products to military use.

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	FY 2003	FY 2004	FY 2005
Electric Curtain	0.000	5.031	5.848

(U) The Navy's Sea Power 21 vision requires future naval forces to have assured access to littoral waters. Sea Strike forces must have the ability to conduct maritime operations in the presence of diesel submarine threats and surface craft capable of launching wake homing torpedoes. Based on promising results investigated under the Lorentz Force Turbulence Control (LFTC) project under the Friction Drag Reduction program and the HEDLight program (both of which are budgeted in separate lines in this project), the Electric Curtain program will demonstrate the feasibility of using an array of transducers to form a destructive pressure pulse capable of disabling an enemy's torpedo. Of critical importance is the ability to accurately predict non-linear pressure pulse propagation effects and corresponding timing delays used during pressure pulse generation and beamforming. Additionally, the beamformed pressure pulse must be of sufficient amplitude and duration to destroy a wake homing torpedo at tactically significant ranges.

(U) Program Plans:
- Conduct non-linear pressure pulse propagation modeling and assess projected system performance.
- Design, develop and test transducer module.
- Incorporate ship wake effects into the pressure pulse propagation model.
- Design, develop, and test ¼ scale transducer array.
- Conduct ¼ scale system testing.

	FY 2003	FY 2004	FY 2005
Electric Field Signature Sensors	0.000	0.000	3.990

(U) The Electric Field Signature Sensors program will develop passive detection and targeting systems for maritime applications. Ordinary surface and subsurface motion causes disruptions in the earth's naturally present electrostatic field that can be detected with highly sensitive sensors. The goal of this program is to exploit this E-field phenomenon through the integration and demonstration of enabling technologies in tactically relevant systems. Such systems will dramatically increase combat situational awareness and directly contribute to enhanced defensive

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and offensive operational capabilities. Potential applications include counter small-arms systems for helicopters, surface contact situational awareness systems for submarines, and Anti-Submarine Warfare.

(U) Program Plans:

- Characterize electrostatic signatures within the battlespace environment.
- Conduct operational concept development and analysis for multiple mission applications.
- Develop low cost electrostatic sensors for a robust military environment.
- Design, fabricate, integrate, and test in an tactically relevant system application.

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

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

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Land Systems Technology TT-04	34.910	40.028	69.397	97.979	97.311	100.463	88.246

(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: Novel Sensors for Force Protection; Dynamic Optical Tags (DOTS); Guided Projectiles, Networking Extreme Environments (NetEx); Stimulated Isomer Energy Release (SIER), MAgneto Hydrodynamic Explosives Munition (MAHEM), Compact Military Engines, Anti-Sniper, and Vertical Infiltration, Persistent Extraction Robot (VIPER).

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

	FY 2003	FY 2004	FY 2005
Novel Sensors for Force Protection	11.784	8.719	12.810

(U) The Novel Sensors for Force Protection program (formerly known as the Close-In Sensing Program) is exploring and developing a variety of novel methods that will contribute to enhance protection of U.S. warfighters. Concepts for the projects originated in DARPA's Close-In Sensing program and have now matured into specific approaches that have been heavily influenced by situations encountered by U.S. warfighters in the Global War on Terrorism, Operation Enduring Freedom and Operation Iraqi Freedom. The motivation behind all the programs is to reduce the exposure of U.S. warfighters when they are operating in disadvantageous territory, especially those complex settings (densely populated and structured areas, multi-storied buildings, etc.) typically found in urban settings. The technologies investigated in Close-In Sensing considered new hardware and approaches to detect traditionally low signal-to-noise or concealed targets without placing people in harm's way and include infiltration and exfiltration technologies to incorporate sensor data reachback capability. Novel Sensors program consists of the Unique Signature Detection Project (formerly known as the Odortype Detection program), the Enemy Dismount Intrusion Detection Project, the Urban Vision Project, the Explosives Detection Project and the Anti Sniper Project. Because of the multiple potential uses beyond close-in sensing in urban

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environments the Dynamic Optical Tags Program (DOTS), which was previously budgeted in this section in FYs 2003 through 2005 under the Close-In Sensing Program, has been delineated into its own narrative elsewhere in this PE/Project.

(U) The objective of the Unique Signature Detection Project is to determine whether there are unique signatures in emanations that can be used to identify and distinguish specific high-level-of-interest individuals within groups of enemy troops or combatants, and if so, to develop enabling technology for detecting and identifying those specific individuals. The program leverages research that demonstrated 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 unique emanated signatures. Although experimental data for humans is far less quantitative, behavioral studies have yielded compelling results to suggest that such phenomenology can also be expected in humans. Recent experimental results with mice suggest that MHC-determined urinary signatures are expressed in a mixture of volatile carboxylic acids occurring in relative concentrations that are characteristic of the emanation. This suggests the possibility of a corresponding unique and exploitable chemosignal. Accordingly, the program will design detectors that exploit this phenomenon by reliably detecting and identifying specific signatures of interest. The program will first characterize the nature of the signal, and determine its robustness in the presence of background signals. If an exploitable robust signature is identified, the program will then pursue detector development. Such detectors would enable U.S. troops to remotely detect the presence of high-level-of-interest individuals within groups of enemy troops or combatants with high reliability.

(U) The Enemy Dismount Intrusion Detection Project will develop a chemical sensor that is capable of providing an advanced warning of the presence of enemy troops or combatants by detecting the chemical emissions or pattern of emissions that are common to all humans and therefore would be common to all enemy dismounted troops or combatants, but are otherwise not ordinarily encountered in the environment. This program will leverage capabilities found in nature to recognize and locate the volatile chemicals that are the most reliable indicator of the presence of enemy troops or combatants. This program first seeks to observe operation of organic sensoring modalities in order to develop a fundamental understanding of these chemical emissions and their relationship to enemy troops or combatants. With this knowledge, a sensor and detection scheme can be developed that will be capable and robust against false alarms. This detection capability would provide advanced threat warning to troops involved in perimeter defense and similar operations.

(U) The Urban Vision Project will develop the technology and systems to provide the warfighter with an advanced in-depth view of the distribution and location of dielectric bodies that resemble those of enemy dismounted troops or combatants within a building in an urban area. The envisioned system is an array of UAVs surrounding the location of interest (building, wooded area, etc.). Each node of the array carries a

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suite of low-power multi-spectral transmitters and receivers that act in concert with real-time electromagnetic analysis codes to "peel back" the structure of the building and the disposition of signatures that are indicative of enemy dismounted troops or combatants within.

(U) The Explosives Detection Project seeks to develop a system of technologies capable of standoff (non-contact) detection of explosive compounds. Of particular importance are high throughput applications, such as military checkpoints, where an extremely low false alarm rate is required. Rather than promoting a single, particular technology, this program will develop a systematic framework of understanding for both the target and background signals. With such an understanding, concepts such as sensor fusion and the optimum setting of thresholds can be properly optimized. In this manner, a system of sensors can be developed that has reliable detection capabilities in both laboratory and field environments. This capability will greatly reduce the threat of suicide bombing and similar tactics faced by troops in the field.

(U) Program Plans:

- Close-In Sensing.
  - Continued trade off studies in advanced technologies for use in data infiltration and exfiltration.
  - Evaluated novel delivery methods and platforms to enable target proximate access of sensor systems, including robotic and fiber optic technologies.
  - Explored multi-sensor architectures and waveforms.
  - Explored novel radio frequency exploitation concepts.
  - Investigated sensor reachback technologies.

- Unique Signatures Detection.
  - Identify the chemical make-up of MHC-determined unique signatures.
  - Examine the chemistry and impact of non-genetic background signals.
  - Design detectors that are capable of identifying high-level-of-interest individuals within groups of enemy troops or combatants through unique, specific signatures with high reliability.

- Enemy Dismount Intrusion Detection.
  - Examine chemical emissions that are unique to humans and therefore to all enemy dismounted troops and combatants.
  - Examine background chemical signals in a variety of environments.
  - Design detectors capable of reliably indicating the presence of enemy dismounted troops and combatants with a low false alarm rate.

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- Urban Vision.
  - Design, develop, and evaluate an initial (fixed placement) multi-static multi-frequency dielectric imaging array test system.
  - Establish baseline system performance parameters for spatial resolution and dielelectric differentiation.
  - Develop algorithms for inverting the multi-static imaging data to reveal the interior structure and distribution of objects within the structure, and the coarse categorization of those objects with sizes typically associated with enemy troops or combatants and dielectric characteristics.
  - Design, develop, and demonstrate UAV array multi-static dielectric tomography imaging system.

- Explosives Detection.
  - Examine current and emerging technology.
  - Develop an understanding of background conditions in varying environments.
  - Design detectors capable of reliable, low false alarm, stand-off explosives detection.

	FY 2003	FY 2004	FY 2005
Dynamic Optical Tags (DOTS)	2.584	5.947	8.819

(U) Based on the technical successes and demonstrated operational relevance of DARPA's now completed Optical Tags program, the Dynamic Optical Tags program seeks to create new tagging, tracking, and location capabilities for U.S. Forces. The program was budgeted under the Close In Sensing program but has now been broken out separately for enhanced visibility. This program will develop optical tagging and interrogation technologies that will enable small environmentally robust, retro reflector-based 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 or monitoring tactical areas for disturbance from personnel and vehicles. The identification tags also will be capable of providing persistent two-way communications for both tactical and logistics operations.

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(U) Program Plans:
- Identify promising retro reflecting techniques.
- Develop most promising retro reflecting techniques into tag design.
- Develop handheld and airborne interrogation systems.
- Integrate and test components in a fully functional configuration.

	FY 2003	FY 2004	FY 2005
Guided Projectiles	13.589	10.868	15.977

(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 targets, such as anti-ship cruise missiles, ground-to-air and ground-to-ground threats. This program has been combined with the Collaborative Munitions efforts, which seek to expand the functionality and lethality of munitions by enabling new ways for them to collectively accomplish difficult and time critical missions, and are based on the success of the Antipersonnel Landmines Alternatives (APLA) program (completed in FY 2002). This program will also develop enabling technologies to give U.S. warfighters the ability to allow weapons platforms, such as mortars, receive updated target information from other munitions or sense target changes on their own. Based upon this information, the platforms can adjust course in flight to prosecute highly mobile, time sensitive targets such as those encountered during Operation Enduring Freedom. This program will adapt recent advances in communications, computers, ad-hoc networking, sensing 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) Specifically, the program seeks to develop a low-cost, non-imaging optical laser seeker using new technology. The goal is to replace the current 60mm mortar fuze with the laser seeker. This will greatly improve firing precision. Additionally, research will be done with explosives to improve the effectiveness of 60mm explosive rounds. The goal is to develop a 60mm projectile with the effectiveness of a 105mm high explosive projectile. Additionally, the program will exploit dismounted, close-in attack scenarios to develop small aperture, geolocation capability for a new-class of anti-radiation weaponry. This program will enable a suite of weapons that home on RF energy emitted by enemy forces to include ground-to-ground, air-to-ground, and ground-to-air weapons all using similar RF sensor guidance technology. The result of this effort will create a passive, all-weather, and inexpensive precision targeting capability for precision and area suppression weapons and counter enemy signals

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camouflage, concealment and detection efforts. The initial effort will focus on providing an RF homing guidance and warhead package that is capable of being fired out of an 81mm mortar.

(U) A portion of this program will investigate supersonic interceptors that provide high rate, multiple engagement defense of critical tactical or strategic assets, including naval surface ships, airborne 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.
- Conduct preliminary development and evaluation of key subsystem technologies.
- Perform initial flight demonstrations and target acquisition demonstrations.
- 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.
- Develop mortar seeker using an array of non-imaging optical lenses.
- Develop small and responsive control/steering fin system.
- Combine seeker with control/steering system into a package that replaces the current fuze on the 60mm mortar high explosive round.
- Develop small, moving aperture geolocation techniques, such as tomographic geolocation.
- Investigate techniques for the reduction of channel mismatch errors, such as spinning the mortar to remove bias errors.
- Research multipath mitigation and multiple user discrimination techniques, such as subspace tracking techniques.
- Develop mortar-sized electronics and guidance package.
- Demonstrate tube launch of 81mm RF guided mortar round and field realizable cueing system in conjunction with transition partner.
- Initial design of mortar mounted RF seeker and mortar control system.

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	FY 2003	FY 2004	FY 2005
Networking Extreme Environments (NetEx)	6.953	5.858	8.425

(U) 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.

(U) Program Plans:

- Characterized the effect of UWB system operation on military radio frequency receivers.
- Determined the thresholds of interference of UWB, which are caused by legacy equipment and methods by which it can be reduced.
- Develop an improved UWB physical layer.
- Develop a Tactical Voice/Data Radio (TVDR) with Multilateral Geolocation Ranging.
- Develop a Low Bit Rate Sensor Network with highly accurate geolocation.
- 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 2003	FY 2004	FY 2005
Stimulated Isomer Energy Release (SIER)	0.000	3.000	4.000

(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 Stimulated 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

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gram-size quantities. The program will demonstrate that as much energy can be released as is used to initiate the reaction (a breakeven experiment).

(U) Program Plans:

- Determine if the hafnium isomer can be triggered with photons in the x-ray range that will release more than 50 times the energy input of the trigger.
- Identify a hafnium isomer production process that is affordable and cost effective.
- Develop a physics approach to a chain reaction for the hafnium isomer.

	FY 2003	FY 2004	FY 2005
MAgneto Hydrodynamic Explosive Munition (MAHEM)	0.000	0.000	4.200

(U) Based on concepts identified under the collaborative munitions program (budgeted under this PE/Project), the MAgnetoHydrodynamic Explosive Munition (MAHEM) program will demonstrate compressed magnetic flux generator (CMFG)-driven magnetohydrodynamically formed metal jets and self forging penetrators with significantly improved performance over explosively formed jets and fragments. Explosively formed jets (EFJ) and self forging penetrators (SFP) are used for precision strike against targets such as armored vehicles and reinforced structures. Current technology uses chemical explosive energy to form the jets and fragments. This is highly inefficient and requires precise machining of the metal liners from which the fragments and jets are formed. Generating multiple jets or fragments from a single explosive is difficult, and the timing of the multiple jets or fragments cannot be controlled. MAHEM offers the potential for higher efficiency, greater control, the ability to generate and accurately time multiple jets and fragments from a single charge, and the potential for aimable, multiple warheads with a much higher EFJ velocity, hence increased lethality and kill precision, than conventional EFJ/SFP. MAHEM could be packaged into a missile, projectile or other platform and delivered close to target for final engagement and kill. This could provide the warfighter with a means to address stressing missions such as: lightweight active self-protection for Future Combat Systems (FCS) vehicles (potential defeat mechanism for a kinetic energy round); counter armor (passive, reactive, and active); mine countermeasures; and anti-ship cruise missile final layer of defense.

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(U) Program Plans:
- Refine magnetohydrodynamic models of MAHEM behavior.
- Conduct capacitor-driven liner experiments to validate models.
- Complete single and multiple-liner CMFG and MAHEM concept designs.
- Develop and conduct experiment demonstration of CMFG and CMFG-driven MAHEM

	FY 2003	FY 2004	FY 2005
Compact Military Engines	0.000	2.000	6.066

(U) As military systems become more mobile and autonomous and able to carry out missions with greater endurance, they will require a new generation of engines that are lighter, more compact and consume less fuel. Further, the military is requiring that the new generation of engines consume only logistic fuel (JP-8). The Compact Military Engines Program will apply innovative ideas for engine design to produce performance gains not obtainable by further refinement of conventional designs. The ideas will, for example, eliminate heavy accessory components, such as the valve drive trains, and eliminate sources of lost power, such as piston side forces causing friction and thermal conduction through cylinder walls. The Compact Military Engines Program will address engine types and diverse missions. The goal of the program is to decrease the size of mobile electric power generators by a factor of ten. Improvements to electric generators for hybrid electric vehicles will increase vehicle range and endurance.

(U) Program Plans:
- Complete concept design.
- Demonstrate critical technologies.
- Build and test prototype engines to demonstrate continuous operation at substantial power levels.
- Build and test prototype engines to demonstrate full performance.

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	FY 2003	FY 2004	FY 2005
CrossHairs	0.000	1.636	4.000

(U) This program will apply the techniques developed in the Novel Sensors program to rapidly develop methods and equipment to enable blue-team forces to detect, locate, and engage shooters and defeat Rocket Propelled Grenades (RPGs), Anti-Tank Guided Missiles (ATGMs), etc. in urban environments. Location will be made with sufficient timeliness for effective counteraction and shooter elimination. This will be achieved with minimal exposure of blue-team forces to further attack. A combination of techniques will be used to achieve these goals. Technologies may include high-speed IR imaging to determine bullet and RPG trajectories and backtrack to shooter origin, automated responses such as imaging for forensic and judicial evidence, rapid dissemination of shot location to combatants to allow both effective concealment and counterfire, protective measures against RPGs followed by counterfire, and elimination of threats. The Concept of Operations is to provide HUMMWV mounted detection and response systems while on the move and a lightweight portable freestanding low power unit for platoon or squadrons while stationary. Techniques for supporting detection and false-alarm rate mitigation will be considered, including acoustic detection, optical, radar and sniper scope detection. It is envisioned that the system will provide a significantly improved capability to detect and engage snipers during hostile and peacekeeping operations in both urban and non-urban environments. Technology challenges of particular interest are: low false rate algorithms, quick reactive sensor techniques for a 360 degrees azimuth and 60 degree elevation detection zone; robust data collection for tracking firing source; and fast response solutions. The program will culminate with a series of prototype demonstrations of the system(s) in typical combat environments.

(U) Program Plans:

- Develop fast response system concepts in coordination with user input.
- Identify and develop ultra-fast sensors and algorithms to detect and track in near real time.
- Perform component testing and conduct detection and tracking demonstrations.
- Analyze data and integrate response system.

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	FY 2003	FY 2004	FY 2005
Vertical Infiltration, Persistent Extraction Robot (VIPER)	0.000	2.000	5.100

(U) This program will apply concepts from the Novel Sensors program to the development of a serpentine platform with a small body diameter and three-dimensional mobility. The VIPER platform will be able to support a variety of operational missions including surveillance of areas that are beyond the reach of current robotic platforms, as well as sensing, searching and providing the warfighter with information that cannot be obtained by current systems. Technical challenges to the development of a high-degree-of-freedom robot include: power generation, management and storage; locomotion; terrain and situational awareness; navigation and control; system infiltration and data exfiltration; health and status monitoring; and position and configuration management. Solutions to these challenges will be developed to support urban operation concepts.

(U) Program Plans:
- Perform a risk reduction and feasibility demonstration phase of the basic platform.
- Develop the integrated robotic system and multiple degree-of-freedom operator control software.
- Complete extensive system testing to characterize system performance.
- Demonstrate system capabilities to potential users.

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

- Not Applicable.

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Tactical Technology TT-06	64.030	90.703	112.287	116.767	119.141	133.673	133.530

(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. Studies under this project examine innovative approaches to non-invasive weapons detection, the use of laser and fiber-optic technologies to increase the survivability and lethality of existing systems, and the development of miniaturized and technologically advanced sensors, algorithms, and devices for monitoring assets.

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

	FY 2003	FY 2004	FY 2005
High Power Fiber Lasers	6.954	11.787	13.770

(U) The High Power Fiber Lasers program will develop and demonstrate single mode fiber lasers with output powers of 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 single mode polarized output power from a single large mode-field area fiber.
- Demonstrate greater than 1 kilowatt single mode polarized output power from a single large mode-field area fiber.
- 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 2003	FY 2004	FY 2005
High Powered Femto Second Laser Diodes	5.632	3.285	3.151

(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 system could lead to incredible advances in micromachining, communications, ultra-short pulse spectroscopy, light detection and ranging (lidar), and directed energy applications.

(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 system with a 10 kHz repetition rate that can fit into a shoebox. 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.

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	FY 2003	FY 2004	FY 2005
Super High Efficiency Diode Sources (SHEDS)	1.790	6.770	4.801

(U) The goal of the SHEDS (formerly High Average Power Solid State Laser) program is to develop laser diodes that are 80% efficient in converting electrical power to optical power. These will be used for supplying the optical power to ytterbium and neodymium solid state lasers operating near 1060 nm. Such high efficiency laser pumps for these solid state lasers will lead to dramatic reductions in the size and weight of 100kW class diode pumped solid state lasers.

(U) Program Plans:

- Achieve 80% efficiency from single diode bars.
- Achieve spectral range of 880nm to 980nm, the range for pumping directly into the upper laser level of Nd and Yb.
- Provide wavelength stabilization to prevent thermal drift of the diode bar wavelength outside of the range of high absorption of the laser transition.
- Achieve a power level of 480W/cm^2 per diode stack operating continuously.
- Achieve a peak power of 2000W/cm^2 for operating the stacks in a quasi-continuous wave (CW) mode with a duty cycle of no less than 25%.
- Achieve much more efficient diode stacks that will reduce the waste heat to one third of that generated by currently available diode bars.

	FY 2003	FY 2004	FY 2005
High Energy Liquid Laser Area Defense System (HELLADS)	5.221	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

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lightweight HEL weapon system. HELLADS will design, fabricate and test a prototype laser. A laboratory demonstration of key performance parameters will be performed, followed by the fabrication and testing of a subscale HEL laser. 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.

(U) Program Plans:

- Conduct key technology demonstrations of resonator stability, laser gain, and system thermal performance.
- Develop and test a 10-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 2003	FY 2004	FY 2005
Laser Star	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 sensor/target signal cancellation. 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. Laser Star technologies are being developed to overcome these shortfalls.

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

	FY 2003	FY 2004	FY 2005
Coherent Communications, Imaging and Targeting	5.518	8.872	12.800

(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 (greater than 1000 kilometers) and targeting at very long ranges. Innovative design concepts for MEMs based Spatial Light Modulators (SLMs), which provide a quantum leap in digital 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 from ground to space in a highly aberrating environment. The CCIT system will address the critical need for high-data-rate communications and imaging from land, sea and airborne platforms to space.

(U) The counter swarm offense and defense project will explore innovative concepts for defending high value ships and ports against multiple missiles, fast boats and airborne threats, and offense against multiple ground targets in all weather conditions. New capabilities achieved by advances in SLMs allow for seamless transfer or hand-off of digital radar target acquisition data. By imprinting target locations on SLMs, multiple targets can be simultaneously designated in parallel with orthogonal codes consisting of spatial (amplitude) and temporal (phase) modulations. This allows for a single laser designator system to direct precision or semi-active laser guided munitions to a large number of incoming closely spaced threats. In addition, the program will seek to decrease degradation of accuracy or cross talk between guidance signals by assigning unique orthogonal codes to the interceptors to prevent spoofing.

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(U) The high data-rate optical communications project will exploit the characteristics of CCIT SLMs to dynamically generate orbital angular momentum (OAM) of photons. Using SLMS to change the OAM of photons in real-time as opposed to simply modulating the amplitude of light waves allows for significant improvement in data carrying capacity. The program will also develop system level architectures for secure free space optical communication networks.

(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.
- Concept development of target acquisition and hand-off to SLM arrays.
- Develop concept for unambiguous resolution and detection of OAM states.
- Conduct computer modeling of OAM modification.
- Design laser transmitter and receivers.
- Develop orthogonal code.
- Develop prototype system with high-speed parallel electronics and demonstrate ground to space communication links and aberration-free imaging.

	FY 2003	FY 2004	FY 2005
High Performance Algorithm Development/Virtual Electromagnetic Test Range	10.116	11.775	13.409

(U) The programs in this area 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. They also cultivate theoretical breakthroughs in areas of basic mathematics having relevance to emerging Defense sciences and technologies. 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 digital representation and analysis of terrain and other geospatial data, efficient high fidelity scattering computations

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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. Expand to include dynamic and rough-surface scatterers with particular emphasis on radar signature prediction and design for naval vessels.
- 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 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. Exploit multiple scattering and clutter to enable increased communication bandwidth at fixed power in acoustic and wireless applications.
- Create new system-level algorithms that are able to design and guarantee performance of complex systems while managing the uncertainty that is inherent in large, multiscale, highly interconnected systems where dynamics are important.
- Apply modern algorithmic approaches to battlefield modeling using stochastic, algebraic, and differential equations as well as Hidden Markov Models.
- Develop approaches to software design and optimization to dramatically reduce time and cost of the production of high-performance software for sensing and communications systems.

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	FY 2003	FY 2004	FY 2005
Integrated Sensing and Processing	8.494	8.697	8.139

(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 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.

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– 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 2003	FY 2004	FY 2005
Mission Specific Processing (MSP)	6.720	4.527	4.023

(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 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.
– 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.
– Demonstrate a ten-fold performance improvement in custom radar signal processing chips.
– Complete library of key digital signal processing function kernels and supporting tool augmentations.
– Complete development and demonstration of space-time adaptive processor for seeker-receiver.
– Conduct first pass evaluation of semi-custom, full scale chip in a space-time 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 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 2003	FY 2004	FY 2005
Water Rocket	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. 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 maneuvered, moved into higher orbits, and refueled to accomplish advanced missions.

(U) Program Plans:
- Perform critical technology demonstrations and analysis of the system for the regenerative fuel cell and other developmental components.
- Design, fabricate, and test a baseboard regenerative fuel cell system demonstrating performance and endurance.

	FY 2003	FY 2004	FY 2005
Training Superiority	5.950	12.338	15.029

(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.

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(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.
- 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.
- Exploit automated semantic analysis and multiplayer games to dramatically improve the training of teams and provide real-time feedback on team performance.
- Explore approaches for creating high-level cognitive competence through "training" of related non-cognitive functions.

	FY 2003	FY 2004	FY 2005
Language and Speech Exploitation of Resources Advanced Concept Technology Demo	0.940	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:

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

	FY 2003	FY 2004	FY 2005
Air Laser	0.000	0.000	6.000

(U) The Air Laser program will investigate the potential for a high energy laser (HEL) concept based on direct diode pumping of liquid oxygen. If successful, the Air Laser could provide a safe, efficient hundred kilowatt-class HEL which combines the advantages of chemical and solid state lasers and minimizes the disadvantages: it operates in the eye-safe wavelength regime; it uses liquid air as the gain medium and as the diode array coolant, resulting in the reduction or elimination of a separate thermal control system; the use of efficient, high energy density diode pump sources, results in a compact device much smaller than either chemical or solid state lasers; and its pulse length is variable from continuous to sub-picosecond, allowing flexibility in weapons effects.

(U) Program Plans:
– Perform system/utility analyses.
– Develop and demonstrate 4 kW laser design.
– Develop and demonstrate 20kW laser design.
– Develop 100 kW laser design.
– Develop kilowatt-class red diodes.

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	FY 2003	FY 2004	FY 2005
Rapid Checkpoint Screening	0.000	1.481	4.310

(U) The Rapid Checkpoint Screening program (formerly Deception Detection funded from PE 0602301E, ST-28) will develop and demonstrate techniques and sensors to detect life-threatening deceptions in military controlled portals such as military checkpoints that are compatible with existing portal screen approaches.

(U) Program Plans:

- Identify physiological signals that correlate with deception including laser vibrometry, lidars, multi-spectral eye tracking, and short range electrical potential.
- Validate the measurement process.
- Establish new concepts for understanding deception processes on a scientific basis.

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

- Not Applicable.

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Aeronautics Technology TT-07	21.739	16.229	41.760	46.377	39.314	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. This includes advanced technology studies of revolutionary propulsion and vehicle concepts; sophisticated fabrication methods and examination of novel materials for aeronautic system applications.

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

	FY 2003	FY 2004	FY 2005
Micro Adaptive Flow Control (MAFC)	9.614	7.172	7.200

(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 three of the most promising applications will be evaluated in full-scale adaptive flow control demonstrations. The first Phase III demonstration took place in July 2003, and used synthetic jets on a tiltrotor aircraft placed in the flap and aileron to demonstrate flow control. This test reduced the download on the XV-15 by 14%. This amount of download reduction, if applied to the V-22, would enable a payload increase of 1000 lbs. Leading technical challenges include the development of robust actuators with the required force, displacement, and bandwidth for robust applications, and the integration of novel actuators including combustion gas actuation, phased

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plasma actuators, and synthetic jets with MEMS-based flow sensors and embedded, adaptive controllers. These challenges require the development of new approaches for power conditioning and distribution, and the definition and implementation of control system architectures, including embedded sensing, data communication, processing and actuation. A second Phase III demonstration of the Boeing High Frequency Excitation for Supersonic Weapons Release (HIFEX) system will be tested at Holloman Air Force Base on a rocket sled in 2005. This system will allow for safe weapons release at speeds in excess of Mach 2. The last Phase III demonstration will be the Georgia Tech Research Institute (GTRI) and Army Research Lab (ARL) Self Correcting Projectile for Infantry Operations (SCORPION); currently a piezo-electric actuated control system for 40mm grenades. Recent testing performed at the Aberdeen Proving Grounds in Aberdeen, MD demonstrated that firing the piezo-electric actuator against the weapon's coanda surface provides more than enough control authority to meet and exceed program goals. Three full-scale demos will take place in 2005 with an emphasis on moving towards smaller caliber and faster weapons. The actuation system will also be upgraded from piezo-electric to gas generating solid propellants.

(U) Technologies involving aerodynamic surface flow control will be further developed and refined under the Solid State Multifunctional Micro Air Vehicle (SSMAV) effort. SSMAV will provide an order of magnitude improvement in control authority to navigate in complex environments under gusts up to 20 mph by leveraging the use of solid state micro chemical thrusters (jets) embedded in the aerodynamic surface of the micro air vehicle. This will provide multi-functionality that enables the aerodynamic surface to serve as a source of lift as well as control and sensing. The jets are used to locally disturb the flow over the vehicle in the low Reynolds number regime to enable high maneuverability and precise navigation. In addition, the thrusters can be used to change the stall and drag properties of an air vehicle to rapidly slow it down from a glide trajectory to perch on the top of a building without being detected.

(U) Program Plans:

- Executed Phase II, high speed, closed loop technology demonstrations.
- Successfully executed MAFC download reduction testing on the XV-15.
- Continue to identify Phase III follow on efforts from the projects with the most promising Phase II results.
- Complete sled design and fabrication for HIFEX phase III test.
- Complete HIFEX system design and fabrication for HIFEX phase III test.
- Complete SCORPION system design and fabrication for SCORPION phase III test.
- Design and integrate SCORPION full-scale control system.
- Configure and execute Phase III full-scale technology demonstrations.
- Evaluate advanced composite manufacturing techniques for air vehicles and flow control.

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- Develop SSMAV system level requirements, control authority, navigation accuracy.
- Conduct detailed simulation studies to determine enhanced range and precision capability with chemical thruster jets.
- Conduct experimental wind tunnel tests with candidate fixed wing/rotary wing micro air vehicle (2 to 6 inches in size).
- Conduct experimental wind tunnel tests with integrated chemical thruster jets to determine control authority improvement and aerodynamic performance, i.e. stall characteristics of vehicles.

	FY 2003	FY 2004	FY 2005
Small Scale Propulsion Systems (SSPS)	8.125	3.057	3.000

(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.
- Demonstrate multifunctional structure plus battery for micro air vehicle (MAV) wings that yield three times more duration than with traditional wing structures and conventional batteries.
- Investigate compatibility of optical flow and uncooled IR approaches with multifunctional structures to enhance surveillance capability.

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	FY 2003	FY 2004	FY 2005
Peregrine	0.000	0.000	1.410

(U) The Peregrine Unmanned Air Vehicle (UAV) Killer program will develop a small, low-cost, high-endurance UAV, with a high dash speed, capable of destroying most enemy UAVs. Unmanned air vehicles are an emerging threat. Small UAVs with GPS guidance systems have reached such a low cost level that expendable UAV programs are now emerging and GPS capable avionics are available for the hobby market. Current options to counter such a threat, especially at high altitude, involve expensive ground launched anti-air systems or the exposure of manned interceptor aircraft. The Peregrine program will develop and demonstrate a UAV interceptor aircraft that will utilize a dual propulsive power system to provide very high endurance for the loiter and surveillance period, and a very high dash speed for intercept and kill. The program will also identify operating scenarios and system requirements for the protection zone approach for both domestic situations and regions of conflict, and will develop a suitable system design and concept of operations.

(U) Program Plans:
- System requirements definition.
- Develop concept design.
- Demonstrate aircraft performance and kill capability.

	FY 2003	FY 2004	FY 2005
Walrus	4.000	6.000	10.000

(U) Technologies previously reported under the Long Endurance Hydrogen Powered Unmanned Air Vehicle and the Unmanned Tilt Rotor programs have been combined into the Walrus program; these include: high-strength and low structural weight airframes; high efficiency propulsion systems; and heavy-lift cargo transport. The Walrus program will develop and evaluate a very large airlift vehicle concept that is designed to fly heavier-than-air, unlike earlier generation airships. As a "hybrid aircraft," it will generate lift through a combination of aerodynamics and gas buoyancy. The program will develop and construct a Walrus Advanced Technology Demonstration (ATD) air vehicle with

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comparable C-130 airlift capability, and will explore, develop, and demonstrate the system concepts of operation. Scalability of the concept will also be demonstrated. An objective vehicle is envisioned to be capable of lifting over 500 tons across intercontinental distances, being able to transport a Unit of Action (UA) from "Fort-to-Fight" as a complete integrated action-ready package of personnel and equipment. Additionally, Walrus may meet the multi-agency needs of common requirements for extended range airborne patrol, persistence and intra-theater support and re-supply. Two advanced breakthrough technologies that will be investigated in the first phase are: vacuum / air buoyancy compensator tanks, and electrostatic atmospheric ion propulsion. The program's first phase will include system studies and development of a notional concept of the objective vehicle. Based on these studies and concept viability, the competitive second phase will lead to development, design, build and initial flight test of the ATD vehicle. Funding is budgeted is PE0603285E, Project ASP-01 to continue the program past Phase I.

(U) Program Plans:

- System definition and development of notional objective air vehicle concept having a payload capability circa 500 tons.
- Establish the feasibility of breakthrough technologies.
- Develop conceptual designs of ATD air vehicles that will validate the objective air vehicle concept.
- Perform conceptual design and trade studies of air vehicle variants for a variety of mission roles, including study of technology risk reduction, architecture, survivability, and vehicle conservation.

	FY 2003	FY 2004	FY 2005
High Speed / Hypersonic Reusable Demonstration	0.000	0.000	15.000

(U) This initiative continues work to design, develop and demonstrate a combined cycle engine and reusable hypersonic cruiser, and will be conducted in conjunction with the Responsive Access, Small Cargo, Affordable Launch (RASCAL) and Force Application and Launch from CONUS (FALCON) programs (PE 0603285E, Project ASP-02). Ultimately, the studies and developments under this project may result in the first controllable, recoverable, and reusable hypersonic system demonstration. Initial designs will allow for either a manned or unmanned version, and provide viable options for long-range strike and affordable access to space.

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(U) Program Plans:
- Initiate design work for integration of combined cycle engine and reusable hypersonic vehicle with particular focus on engine maturation; combustion control systems; high temperature and leading edge materials; inlet concepts; and aerodynamic control mechanisms.

	FY 2003	FY 2004	FY 2005
Helicopter Rotor Blade Quieting	0.000	0.000	5.150

(U) Studies and performance results from current U.S. military operational systems, as well as other DARPA programs in this project, have shown that it is vital to increase the survivability and lethality of U.S. helicopters by reducing their acoustic signature, thereby making them harder to track and engage. The Helicopter Rotor Blade Quieting program will employ advanced technology to address this objective. Reducing acoustic signature without sacrificing performance requires a significant departure from current rotor blade designs. Because of the exorbitant cost associated with wind tunnel testing, novel blade design must rely on computational modeling to narrow down the experimental test matrix. Today's models are essentially empirical and therefore allow for only small excursions from existing blade designs. This program will address this barrier to novel blade design by leveraging recent advances in computational fluid dynamics (CFD) to develop physics-based predictive design tools that will yield blades with vastly improved acoustic characteristics. The predictive tools will be tested using existing data sets and data collected from fully instrumented small-scale experiments. The tools will then be used to design new blades that yield a significant reduction in low-frequency in-plane signatures compared to a baseline design.

(U) Program Plans:
- Develop predictive blade design tools.
- Validate models using experimental data.
- Use the tools to design new blades that yield a significant reduction in low-frequency, in-plane signature.

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

- Not Applicable.

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Logistics Technology TT-10	19.401	19.662	15.000	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 2003	FY 2004	FY 2005
UltraLog	19.401	19.662	15.000

(U) The UltraLog program provides technologies to make our highly distributed military logistics information systems inherently survivable even in the most hostile kinetic and cyber warfare environments. UltraLog's technical focus 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 test-bed that supports highly detailed component-level and systems-level assessment. The technologies developed under UltraLog will ensure that future logistics information systems can survive directed cyber attack (technologies include: dynamic Public Key Infrastructure management, information rovers, pedigree, dynamic policy-based control, and random routing); 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 deal with the complexity of multiple current operations ranging in tempo from peacetime training to major regional contingencies with proper

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management of plans and priorities (technologies include: assured convergence, adaptive configuration, variable fidelity processes and reactive plan-space management).

(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.
- 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 1000-agent logistics information system that is capable of operating under directed adversary cyber attack and absorbing significant infrastructure loss, with acceptable capabilities and performance degradation during high-tempo military operations.
- Develop, integrate and evaluate technologies to control and optimize the overall supply flow and inventory strategies for logistics support across the joint battlefield, allowing different commodity chains to operate as complex adaptive networks, rather than as fixed logistics chains.

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

- Not Applicable.

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COST (In Millions)	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Network Centric Enabling Technology TT-13	0.000	33.170	53.918	68.431	71.329	74.189	88.744

(U) **Mission Description:**

(U) This project provides technology to build 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 at headquarters. The mission applications 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 are posed and evaluated in the context of robotic forces. These are defined as collections of a few dozen robotic platforms whose operations must be coordinated to achieve specified mission goals.

(U) Technologies developed in this project enable localized, distributed and cross-platform collaborative processing. This allows networks of sensors to rapidly adapt to changing force mixes, communications connectivity and mission objectives. Technologies are demonstrated and evaluated in the laboratory and in hardware-in-the-loop demonstrations. Demonstrations employ both stationary and autonomous mobile platforms. Operational benefits are (1) smaller forward deployment of image and signal analysts; (2) consistent integration of target and environment information; and (3) flexible operational tactics and procedures for finding evasive targets in difficult environments.

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

	FY 2003	FY 2004	FY 2005
Network Embedded Systems Technology	0.000	15.293	15.255

(U) The Networked Embedded Systems Technology (NEST) program provides robust coordination and synthesis services for sensor network systems. These are the key software building blocks needed to enable ad hoc or structured sensor networks consisting of elementary nodes to

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work together. Applications of these systems include localization of snipers by collaborative sensor fusion in real-time (i.e., within two seconds), sensor network based tripwires and chokepoints for detection and discrimination of personnel and vehicles, helmet- or vehicle-mounted sensor arrays for detecting being painted by laser and targeting the source, wide area 24/7 surveillance of long linear structures such as pipelines and borders, etc. These applications require anywhere from a few tens of simple computing nodes arrayed in a network in an ad hoc manner to several tens of thousands of nodes. NEST produces reusable software libraries and design tools that simplify the design task for all such applications. This program was previously funded in PE 0602301E, Project ST-19 in FY 2002 and FY 2003.

(U) Program Plans:

- Design deterministic and probabilistic methods for self-stabilizing protocols for lightweight coordination services such as global clock synchronization, sensor localization, etc.
- Develop design tools for the customization of coordination-services to specific applications based on application requirements and platform characteristics.
- Develop formal modeling and verification techniques for coordination-services and for integrating them.
- Conduct field experiments and demonstrations of NEST technology in a variety of sensor network monitoring and tracking applications of relevance to the Special Forces, the Marines, and the Army.
- Demonstrate real-time synthesis of schedules (e.g., for actuator firing sequences) and services (e.g., for localization, route planning) using phase transition-aware constraint solvers.
- Develop tools for the automatic composition and verification of application-specific coordination service packages. Demonstrate the utility of these tools in a fully integrated system consisting of a large network of heterogeneous sensors.
- Develop tools for remotely reprogramming large scale sensor networks, and services for authentication, and data encryption in such networks.

	FY 2003	FY 2004	FY 2005
Combat Zones That See (CZTS)	0.000	0.000	6.213

(U) The Combat Zones That See (CZTS) project improves force protection for warfighters in foreign urban environments. CZTS provides close-in sensing and extended reconnaissance capabilities using a network of video sensors. CZTS tracks vehicles over wide urban areas using sparse arrays of video cameras, and automatically detects vehicles that may be involved in hostile activities based on the observed tracks. This

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network will produce far too much data for human analysis, so advanced video understanding algorithms embedded in commercial-off-the-shelf hardware systems will monitor video feeds automatically. Reconnaissance, surveillance, and targeting information needed to provide close-in, 24/7 support for military operations in urban terrain (MOUT) will then be generated. CZTS will enable vehicle identification with a 10,000-fold reduction in the bandwidth required to transmit key data across the camera network, and provide the capability to track vehicles non-continuously across extended distances. The CZTS goal is to demonstrate technology packaged into a flexible system deployable from ground positions and from unmanned aerial vehicles.

(U) Program Plans:

- Develop, install and evaluate a Force Protection prototype, on a military base, that employs approximately 30 cameras.
- Demonstrate sustained tracking of individual vehicles using sensors whose fields of view do not overlap.
- Use vehicle track data to calibrate cameras, learn patterns of activity, and retrieve similar or related events from a track database.
- Employ motion-pattern analysis to assist in finding common elements among collected tracks.
- Develop techniques to optimize the location and orientation for emplacing cameras.
- Develop methodologies for the efficient and timely management of the video network.
- Develop, install and evaluate a MOUT-configured prototype using approximately 100 rapidly deployed cameras.

	FY 2003	FY 2004	FY 2005
Automated Battle Management	0.000	9.800	15.800

(U) The pace of battle will continue to increase as more capable platforms, and more effective communication networks, become operational. While experienced commanders will always be needed to formulate strategy and select tactics, the increased pace of battle will require more automation of low-level decision processes such as route-finding, weapon/target pairing, and sensor scheduling. Some elements of these processes, such as collision avoidance and navigation, will be embedded in each platform. However, groups of platforms will be able to execute cooperative tactics to achieve coordinated effects. This cross-platform coordination and synchronization requires new technologies that can carry out aggregate maneuvers and tasks while leveraging the functions embedded in each platform. This program develops novel technologies for multi-platform, automated battle management at the tactical level, in the air, on the ground, and within mobile sensor networks.

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- The Mixed Initiative Control of Automa-teams (MICA) program develops algorithms, software, modeling and simulation capabilities to perform multi-level planning, assessment and control of distributed, autonomous combat forces. MICA provides 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. An open experimental platform will be employed to evaluate these hierarchical battle management and control methodologies with humans-in-the-loop, initially in a simulation and subsequently in a hardware demonstration.

- The Organic Ground Battle Management program is an outgrowth of the Mixed Initiative Control of Automa-Teams (MICA) program. It will enable continuously synchronized reconnaissance, surveillance, and targeting in highly automated ground operations. It accommodates warfighter maneuver, fires and communications. The program develops methods of rapid search for threats. Threat search considers: mission plan, responsive collection of data on local terrain features for route planning, automated search for obstacles and barriers, adjustment of maneuver plan as surveillance results appear, generation of routes around unsearchable threat areas, and positioning and repositioning of communications relays. The program develops techniques for employment of indirect fire as probes. It automates the weapon-to-target assignment and provides integrated weapon guidance and re-assignment. The Organic Ground Battle Management effort will speed insertion of automated ground forces. It promises reduced forward staffing and a leaner logistical trail as it increases the speed and effectiveness of missions to eliminate or avoid threats. The program supports integrated planning of manned and robotic forces while enabling small staffs to produce quality plans and actions.

- The Organic Sensor Exploitation Network (OSEN) program will develop rapid, highly autonomous techniques for sensor exploitation, leveraging technology from the NEST program and support autonomous sensor networks in ground warfare. It is developing 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. OSEN system studies will evaluate the relative value of different sensor mixes against low-flying aircraft, ground vehicles, dismounted infantry and irregular forces. Sensor candidates include electro-optical, infrared, radar, passive RF, acoustic, seismic, and magnetics that may be fixed or mounted on mobile

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platforms. The program accommodates variable communications connectivity; models predict changes caused by line-of-sight occlusions. The goal of OSEN is to provide network-enabling technology for processes currently performed at centralized ground stations and analysis centers. The objective is to move processing closer to the sensor to reduce the need for expensive communications back to a central site, and provide robustness to unexpected loss of platforms, communications disruptions and unpredictable target behavior.

(U) Program Plans:

– Mixed Initiative Control of Automa-teams
  -- Apply and refine algorithms and software to assign autonomous combat vehicles to task-oriented teams.
  -- Apply and refine algorithms and software to assign 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 phase open experimental simulation platform stressing multi-team coordination and cooperative planning of sensor and weapon platforms against difficult ground targets with responsive operator control and intervention.
  -- Demonstrate cooperative management of 2-5 teams of 5-10 platforms and one operator with team self-organization in the presence of active threats.

– Organic Ground Battle Management
  -- Extend recent advances in distributed resource management to address ground warfare.
  -- Develop additional adversarial reasoning techniques to anticipate enemy responses.
  -- Evaluate results with non-operational robotic platforms at a ground warfare training facility.

– Organic Sensor Exploitation Networks (OSEN)
  -- Define representative sensor mixes and operational scenarios.
  -- Perform analytical trade studies to generate representative sensor network components and tactics.
  -- Develop a network node architecture that is adaptable to the devices present at that node.
  -- Prototype candidate algorithms for each function (search, detect, track, identify, correlation, handoff) based on alternative technologies.

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-- Evaluate candidate algorithms in a synthetic environment to calibrate and verify performance models.
-- Insert selected algorithms into a hardware-in-the-loop testbed. Demonstrate practical utility and verify system performance.

	FY 2003	FY 2004	FY 2005
Eyes-On System	0.000	3.132	5.350

(U) The goal of the Eyes-On (EyO) program is to develop multifunctional information gathering capability for an air launched micro-Unmanned Air Vehicle (micro-UAV). EyO employs very high-resolution, commercial off-the-shelf electro-optical/infrared sensors integrated into a low-signature sensing platform. Commanders can employ the system to achieve visual human-in-the-loop confirmation of targets 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 also allow Eyes-On to support real-time bomb damage assessment following an attack. EyO utilizes line-of-sight RF communications and local command and control system technologies to deliver exquisite just-in-time visual confirmation to the warfighter. The program is developing the capability to support discrimination between non-combatants and combatants. As a forward-deployed, loitering micro-robotic forward area controller, EyO could support long range weapon delivery by monitoring the target area throughout the weapon fly-out. EyO is adapting existing sensor and platform designs and fabricating prototype small UAVs in prototype quantities. Each prototype consists of the air vehicle, a sensor package, flight control system, and data link to the launch platform.

(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 2003	FY 2004	FY 2005
Urban Warfare Robotic Surveillance (URS)	0.000	0.000	2.000

(U) The Urban Warfare Robotic Surveillance System (URS) program will develop new mobile sensor systems, carried on both long-endurance ground and short-endurance air platforms, to support warfighter operations in constrained urban environments. URS is exploring a mix of sensor technologies (EO/IR video, active optics, radar, acoustic, magnetic, chemical and RF direction finding). Sensors are being tested in environments characterized by complex multipath propagation, limited lines of sight and frequent obscuration. Platforms and sensor networks are designed to operate in urban exterior, underground and indoor environments. Communications repeaters and routers are included for terrestrial connectivity to all platforms. They also provide for autonomous operation if communications are interrupted. The program includes means to resupply fuel and power to forward-deployed platforms. A program demonstration will deliver a prototype robotic squad that will provide integrated urban surveillance to augment or replace dismounted infantry in dangerous operations. URS missions 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.
- Derive tasks and functions 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, and route generation and communications management).
- Compare alternatives in the synthetic testbed. 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.
- Improve sensors or algorithms that limit performance.

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	FY 2003	FY 2004	FY 2005
Home Field	0.000	0.000	3.500

(U) The Home Field program will develop sensor and sensor control networks that rapidly and reliably acquire all the information needed to plan and execute military operations. It will acquire information with sufficient detail and accuracy to take away the "home field advantage" enjoyed by opponents. Detailed mobility maps to support ground vehicle routing will be inferred and generated, and detailed visibility data to support sensor positioning will be derived that will maximize coverage and minimize detectability. It will build high fidelity multiphenomenological bases for change detection that can cue searches for targets, and anticipate changes due to current or impending meteorological events. Real-time context information to sensor managers, maneuver controllers, weapons operators, and commanders will be supplied. The program will help filter natural change from artificial change indicative of human (threat) activity. It will permit operation of military forces in hostile terrain normally deemed favorable to opponents because of their historical familiarity with hide points, sight lines, and mobility characteristics. Finally, Home Field will provide selective, highly detailed context information to commanders of field units, and to battle management systems for unmanned ground forces.

(U) Program Plans:

- Demonstrate a 3D model construction method that can use distributed video cameras operating in a mixed contrast environment.
- Demonstrate the ability to extract architectural features such as windows and doors from close-in imagery.
- Demonstrate an effective man-machine interface to edit/update the extracted features.
- Demonstrate prototype planning tools that leverage the extracted urban feature set.
- Demonstrate a model update approach that keeps the urban cartographic representation current.

	FY 2003	FY 2004	FY 2005
Adaptive Reflexive Middleware Systems	0.000	4.945	5.800

(U) The Adaptive and Reflective Middleware Systems (ARMS) program develops fully integrated open system computing and information architecture. Initial focus is on the Total Ship Computing Environment (TSCE) in the DD(X) Future Surface Combatant Family of Ships. The

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technology is applicable to other network-centric DoD systems. The TSCE executes all tasks and mission applications optimized at the platform level, rather than the sub-system level. Autonomous TSCE systems require middleware and frameworks that adapt robustly to quantifiable changes in environmental conditions. ARMS middleware coordinates the exchange of information predictably, scalably, dependably and securely between remote entities. For this it employs advanced Quality of Service (QoS) capabilities of the underlying network and end systems. ARMS was previously funded in PE 0602302E, Project AE-01.

(U) Program Plans:

- Define and prototype adaptive protocols, algorithms, patterns, and tools. Goals are (1) to enforce security policies to enhance and support secure global resource allocation, scheduling, and control; and (2) to 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.
- Demonstrate the dynamic flexibility and QoS in the second DDX TSCE baseline.
- Define and prototype reflective techniques for synthesizing optimized distributed, real-time, and embedded middleware.
- Develop required languages, algorithms, and tools. Configure customizable, standards-compliant TSCE middleware and applications.
- Develop robust adaptive protocols, algorithms, patterns, and tools based on standard middleware. Demonstrate that they can enforce the security policies for global resource allocation, scheduling, and control in the third DDX TSCE baseline.
- Develop and demonstrate robust reflective techniques for synthesizing optimized standards-based middleware in the fourth DDX TSCE baseline.
- Develop and capture design expertise in pattern languages. Formalize 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 for transition to the DD(X) Surface Combatant Family of Ships.

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

- Not Applicable.