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Fiscal Year (FY) 2004/FY 2005 Biennial Budget Estimates

February 2003

RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE

Volume 1 - Defense Advanced Research Projects Agency

UNCLASSIFIED

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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Defense Adv Research Projects Agcy
FY 2004/2005 RDT&E PROGRAM

EXHIBIT R-1

APPROPRIATION: 0400D Research, Development, Test & Eval, DW

Date: FEB 2003

Line No	Program Element Number	Item	Act	FY 2002	FY 2003	FY 2004	FY 2005	SEC
				Thousands of Dollars				
2	0601101E	Defense Research Sciences	1	141,900	199,030	151,029	143,522	U
	Basic Research			**141,900**	**199,030**	**151,029**	**143,522**	
12	0602301E	Computing Systems and Communications Technology	2	349,666	409,256	404,859	479,119	U
13	0602302E	Embedded Software and Pervasive Computing	2	56,190	58,599	13,318		U
14	0602383E	Biological Warfare Defense	2	171,878	161,956	137,254	138,533	U
16	0602702E	Tactical Technology	2	163,827	169,641	250,558	256,175	U
17	0602712E	Materials and Electronics Technology	2	340,446	434,426	465,544	461,043	U
	Applied Research			**1,082,007**	**1,233,878**	**1,271,533**	**1,334,870**	
33	0603285E	Advanced Aerospace Systems	3	131,954	235,300	323,730	340,567	U
41	0603739E	Advanced Electronics Technologies	3	192,895	158,987	174,150	172,151	U
45	0603760E	Command, Control and Communications Systems	3	117,007	117,164	242,738	279,855	U
46	0603762E	Sensor and Guidance Technology	3	190,133	217,378	342,914	354,877	U
47	0603763E	Marine Technology	3	36,141	32,224	13,898		U
48	0603764E	Land Warfare Technology	3	153,017	165,963	82,387	15,433	U
49	0603765E	Classified DARPA Programs	3	118,284	287,695	210,532	246,174	U
50	0603766E	Network-Centric Warfare Technology	3			95,654	151,966	U
	Advanced Technology Development (ATD)			**939,431**	**1,214,711**	**1,486,003**	**1,561,023**	
108	0605114E	BLACK LIGHT	6	5,000				U
118	0605502E	Small Business Innovative Research	6	53,646				U
126	0605898E	Management Headquarters (Research and Development)DARPA	6	36,102	42,271	45,002	46,489	U
	RDT&E Management Support			**94,748**	**42,271**	**45,002**	**46,489**	

Defense Adv Research Projects Agcy
FY 2004/2005 RDT&E PROGRAM EXHIBIT R-1

APPROPRIATION: 0400D Research, Development, Test & Eval, DW Date: FEB 2003

Line No	Program Element Number	Item	Act	FY 2002	FY 2003	FY 2004	FY 2005	SEC
130	0909999E	Financing for Cancelled Account Adjustments	6	2,000				U
		RDT&E Management Support		**2,000**				
		Total Defense Adv Research Projects Agcy		**2,260,086**	**2,689,890**	**2,953,567**	**3,085,904**	

Program Assessment Rating Tool (PART) Information

This year, the Administration undertook a comprehensive review of 20% of the programs of the Executive Branch, including the same portion of programs within the Department of Defense. The Basic Research programs of the Department were reviewed as a whole, including Basic Research programs of the Defense Advanced Research Projects Agency (DARPA). The Basic Research program merited a rating of "Effective". A summary sheet describing the rating from the Basic Research evaluation follows.

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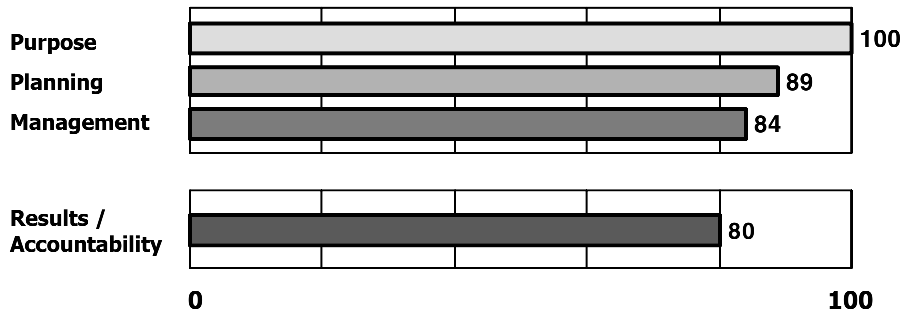
Program: *Basic Research*

Agency: *Department of Defense--Military*

Bureau: *Research, Development, Test, and Evaluation*



- [x] Results Achieved
- [ ] Results Not Demonstrated
- [x] Measures Adequate
- [ ] New Measures Needed

Key Performance Measures	*Year*	*Target*	*Actual*
Certification in biennial reviews by technically competent independent reviewers that the supported work, as a portfolio, is of high quality, serves to advance the national security and is efficiently managed and carried out.	2003 and later	100%	
Long-term Measure: Portion of funded research that is chosen on the basis of merit review Reduce non-merit-reviewed and -determined projects by one half in two years (from 6.0% to 3.0%)	2005	-50%	

Rating: *Effective*

Program Type: *Research and Development*

Program Summary:

The Basic Research program includes scientific study and experimentation to increase fundamental knowledge in the physical, engineering, environmental and life sciences and consists of a wide portfolio of projects. The program is carried out primarily through grants to universities and non-profits. The results of this research are expected to improve the country's defense capabilities, although the actual results of any specific project are unpredictable. Notable successes in the past have led to advances in satellite communications and imagery, precision navigation, stealth, night vision and technologies allowing greatly expanded battlefield awareness. Due to the long-term nature of research results, the R&D PART emphasizes assessment of the process of choosing funded projects and independent assessments of how well the research portfolio is managed.

The assessment indicates that the basic research program has clear purposes of providing options for new weapons systems, helping prevent technological surprise by adversaries, and developing new scientists who will contribute to the DoD mission in the future. DoD can document--through its contracts and grants management regulations, public announcements of award competitions and results from independent review panels--the methodical management of its program. Additional findings include:
1. The grants/contract solicitation, review and award processes are competitive.
2. The program is reviewed regularly by technically capable outside reviewers, which recommend improvements they would like to be implemented. They indicate that the work is of overall high quality.
3. The program has competent planning and management.
4. Earmarking of projects in the program has increased in the past decade and contribute less than the typical research project to meeting the agency's mission.

In response to these findings, the Administration will:
1. Continue to emphasize the use of independent review panels in assessing the performance of the program.
2. Work with the research community and Congress to explain the need to limit claims on research grant funds to proposals that independently can meet the standards of a strict merit-review process.

Program Funding Level (in millions of dollars)

2002 Actual	**2003 Estimate**	**2004 Estimate**
1,334	1,417	1,309

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE February 2003
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, R-1 #2				
COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	141.900	199.030	151.029	143.522	146.283	148.519	151.303	154.081
Bio/Info/Micro Sciences BLS-01	72.657	85.631	87.861	82.099	82.679	84.029	83.948	84.843
Information Sciences CCS-02	8.318	24.094	16.325	15.791	18.592	18.565	18.547	18.528
Electronic Sciences ES-01	23.149	21.924	18.677	20.596	21.527	22.474	25.380	27.306
Materials Sciences MS-01	37.776	67.381	28.166	25.036	23.485	23.451	23.428	23.404

(U) <u>Mission Description:</u>

(U) The Defense Research Sciences Program Element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term National Security enhancement through the discovery of new phenomena and the exploration of the potential of such phenomena for Defense applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic, biological and materials sciences.

(U) The Bio/Info/Micro Sciences project will explore and develop potential technological breakthroughs that exist at the intersection of biology, information technology and micro/physical systems to exploit advances and leverage fundamental discoveries for the development of new technologies, techniques and systems of interest to the DoD. The project will apply information and physical sciences to discover properties of biological systems that cross multiple length scales of biological architecture and function, from the molecular and genetic level through cellular, tissue, organ, and whole organisms' levels. Key focus areas include multidisciplinary programs in BioComputational Systems; Simulation of Bio-Molecular Microsystems; Bio Futures; Biological Adaptation, Assembly, and Manufacturing; Nanostructure in Biology; and Brain Machine Interface.

(U) The Information Sciences project supports basic scientific study and experimentation for national security requirements such as computational models, new mechanisms for performing computation and communication, innovative approaches to the composition of software, novel human computer interfaces, novel computing architectures, and automatic speech recognition research.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, R-1 #2

(U) The Electronic Sciences project explores and demonstrates electronic and optoelectronic devices, circuits and processing concepts that will provide: (1) new technical options for meeting the information gathering, transmission and processing required to maintain near-real time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near-real time; and (2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities.

(U) The Materials Sciences project is concerned with the development of: high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or bimolecular materials, interfaces and microsystems; materials and measurements for molecular-scale electronics and spin-dependent materials and devices.

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

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	142.303	175.646	175.887	176.514
Current President's Budget	141.900	199.030	151.029	143.522
Total Adjustments	-0.403	23.384	-24.858	-32.992
Congressional program reductions	0.000	-7.916		
Congressional increases	0.000	31.300		
Reprogrammings	-0.403	0.000		
SBIR/STTR transfer	0.000	0.000		

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2003
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Applied Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, R-1 #2	

(U) Change Summary Explanation:

FY2002	Decrease reflects below threshold reprogrammings.
FY2003	Increase reflects congressionally added funds in the areas of nanotechnology, optoelectronics, photonics and spin electronics; offset by congressional undistributed reductions.
FY 2004 – 2005	Decreases reflect reprioritization of Agency and Departmental requirements, and re-estimates of anticipated inflation rates.

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RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Bio/Info/Micro Sciences BLS-01	72.657	85.631	87.861	82.099	82.679	84.029	83.948	84.843

(U) Mission Description:

(U) This project will explore and develop the intersections of biology, information technology and micro/physical systems to exploit advances and leverage fundamental discoveries for the development of new technologies, techniques, and systems of interest to the DoD. Programs will draw upon the information and physical sciences to discover properties of biological systems that cross multiple length scales of biological architecture and function, from the molecular and genetic level through cellular, tissue, organ, and whole organism's levels. As such, this project will develop the basic research tools in biology that are unique to the application of biological based solutions to critical Defense problems.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
BioComputational Systems	30.000	30.000	33.000	27.599

(U) The BioComputational Systems component will explore, develop, and exploit computing mechanisms in the bio-substrate as well as develop miniaturized hardware to make the concept feasible for a variety of applications of interest to the DoD. The program seeks to achieve both powerful, synthetic computations that can be implemented in bio-substrates, as well as computational models and software tools for prediction and control of cellular internal processes and systems of living cells, extensible to the organism level. The program will explore two facets of biologically based computation.

(U) First, combining methods for coding information in DNA and related nucleotides will be investigated. By leveraging the massive parallelism capability of nucleotide manipulations, the synthetic computation effort will explore and develop powerful and scalable methods for solving highly complex computational problems, and for designing ultra-high density information storage. To make this concept effective, the program will improve time efficiencies and manufacturing capabilities of biological systems production hardware by miniaturizing it to a circuit

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
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board size system. Self-assembly of DNA will be exploited to develop programmable nano-structures and engineered nano-technology for use in layout of molecular electronic devices, reliable crystallography, and for design of novel materials.

(U) Second, the program will develop validated computational models of internal cellular processes, capturing complex gene and protein interactions, and simulation tools, for in-silico analysis, capable of predicting cellular spatio-temporal dynamics. The application realm includes characterization, prediction, and control of highly conserved mechanisms of interest to DoD, such as those related to pathogenic processes; mechanisms such as circadian rhythms that underlie war fighter performance and well-being in stressed conditions; and design of bio-sensors. The modeling and simulation capability will be extensible from cell level to higher levels such as organ, organism, and to collective groups of organisms. In addition, the program will begin leveraging the modeling, simulation, and bio-informatics capability to explore new methods of biologically inspired computing principles, architecture, and design of robust and reliable information processing and networking systems.

(U) Program Plans:

- Investigate and demonstrate complex scalable information processing using DNA coding and manipulations.
- Develop and implement a progressively sophisticated suite of dynamic cellular models and architecture for Bio-SPICE (Simulation Program for Intra-Cell Evaluation), which will enable modeling, prediction, and control of last submission “cell model” processes, with continual validation of each model experimentally. The cell modeling and Bio-SPICE will be capable of analysis of hundreds of gene-protein networks and interactions. Bio-SPICE version 2.0 released.
- Incorporate spatial models into Bio-SPICE and develop reduced order models capable of analyzing the non-linear and stochastic dynamics of thousands of interactions.
- Demonstrate scalable and extensible implementation of Bio-SPICE that utilizes a distributed computing architecture supporting a rich set of spatio-temporal models, with the ability to handle vast amounts of experimental data for prediction and analysis. Validate biosystem elements that are candidates for intervention strategies in sporulation, cell cycle control, and other processes.
- Demonstrate an array of 2-D self assembled DNA nano-structures and develop a queryable, tagged DNA database with 10K or more information objects coded in strands. Extend this technology to 3-D nanostructures, exploring applications to crystallography.
- Develop preliminary miniaturized hardware designs for oligonucleotide manufacture, manipulation and amplification proof of principle brassboards. Initiate studies on error correction and optimal information encoding of oligonucleotides.
- Finalize miniaturized hardware design for the manufacture, manipulation, and amplification of 10,000 base pair nucleic acid synthesis in 24 hours.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

– Develop miniaturized brassboard (<1/2 ft^3, <25 lbs, <350 watts) hardware applied to the design, manufacture, manipulation, and amplification of 10,000 base pair nucleic acid synthesis in 24 hours.
– Demonstrate and validate that biological systems can be designed and used to solve non-computable or difficult to compute real-world problems.

	FY 2002	FY 2003	FY 2004	FY 2005
Simulation of Bio-Molecular Microsystems (SIMBIOSYS)	14.000	14.764	10.086	3.000

(U) The Simulation of Bio-Molecular Microsystems (SIMBIOSYS) program will focus on methods to dramatically improve the interaction and integration of biological elements with synthetic materials in the context of microsystems. Specifically the SIMBIOSYS program will develop methods and tools to simulate and design Bio-Molecular Microsystems with a high degree of multi-disciplinary integration. This will be accomplished by exploring fundamental properties and compatibility of biological elements at the molecular surface level through experimental and theoretical analyses. Key phenomena to be studied include molecular recognition processes, signal transduction phenomena, and micro- and nano-scale transport of biological molecules. Engineering of biological systems may be used to manipulate these fundamental characteristics and optimize the integration of biological elements with synthetic materials for information collection. It is expected that significant advancements in devices that utilize or mimic biological elements will be realized including sensors, computational devices and dynamic biological materials for force protection and medical devices.

(U) Program Plans:
– Demonstrate high (Signal to noise [SNR] ratio > 10) transduction of molecular signals into measurable electrical and mechanical signals using nanopores, micro/nano-cantilevers, and nanoparticles; demonstrate SNR ~ 100 using solid-state nanopores for DNA translocation and using nanopores for ultraselective DNA detection; demonstrate models to correlate transduced signal intensity to bio-molecular structure and binding events.
– Demonstrate low power transport (~ 10X reduction in power) of fluids by modulating surface tension in droplet based transport.
– Demonstrate surface-tension modulated transport of droplets on a substrate; demonstrate computational models to optimize transport characteristics.

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- Demonstrate orders of magnitude (> 100X) improvement in microfluidic mixing using electrokinetic and Magneto Hydrodynamic (MHD) schemes (based on modeling studies); demonstrate 10 – 100 X improvement in mixing through MHD and electrokinetic instability mechanism.
- Develop scaling laws and phenomenological models for bio-molecular phenomena such as molecular recognition, signal transduction and bio-fluidic transport processes in bio-microfluidic systems; develop and implement scaling laws into microfluidic system modeling software to enable design of lab-on-a-chip systems.
- Design novel hybrid macro-molecular devices that form specific and controlled transducing functions at the molecular scale; demonstrate design of maltose binding proteins and ion channels with desired selectivity and sensitivity using computational tools.
- Design and demonstrate working devices that incorporate biological elements as sensors, actuators and computational devices.

	FY 2002	FY 2003	FY 2004	FY 2005
Bio Futures	11.864	9.997	5.526	2.500

(U) The Bio Futures program will support scientific study and experimentation, emphasizing biological software computation based on biological materials and physical interfaces between electronics and biology, and interactive biology. It will apply information technology to accelerate the analysis and synthesis of biological processes. The seamless integration of information technology and biological processes will provide the ability to exert computational control over biological and chemical processes. The Bio Futures program will also support the development of genomics-based platforms for enhancing the capabilities of biological systems to manufacture, sense, or compute.

(U) Program Plans:

- Manufacture the world's smallest nanofluidic channels (~2 nm in diameter) for parallel processing of single biomolecules; create microfluidic devices for trapping developing insect embryos; create a multi-cantilever field effect transistor for measuring single cell physiology.
- Develop new algorithms based on wavelets and superparamagnetic resonance for sorting neuronal spike data; develop a Bayesian network framework for analysis of cellular regulatory networks; develop a hybrid computational model for representing tissue differentiation in developing embryos; develop a software tool for analysis of high dimensional gene expression data.
- Demonstrate and validate novel nano- and micro-devices for measuring biological systems at the single cell and tissue level.

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– Demonstrate and validate novel computational tools for analyzing and interpreting complex data sets obtained from complex biological systems.

	FY 2002	FY 2003	FY 2004	FY 2005
Biological Adaption, Assembly and Manufacture	6.285	9.500	11.219	15.000

(U) The Biological Adaptation, Assembly and Manufacturing program will examine the structure, function, and informational basis underlying biological system adaptation, particularly to harsh environments, and the factors employed by the organism to assemble and manufacture complex biological subsystems. In the adaptation element, the unique stability afforded biological systems in their ability to adapt to wide extremes of physical and endurance (e.g., heat, cold and sleeplessness) parameters will be examined and exploited in order to engineer stability into biological systems of Defense needs (such as blood or other therapeutics). This will be explored using bioinformatics tools to characterize the differential gene expression that produces tolerance to highly stressful and/or lethal environmental conditions. These "stress gene" products will be analyzed for their ability to improve the survival of living cells and tissues. Tools of metabolic engineering will be applied to afford stability in biological systems of interest.

(U) The assembly and manufacturing element of this component will explore the fundamental developmental and fault tolerance present in biological systems in order to assemble and manufacture complex physical and multi-functional systems. Initial activities in this area will focus at the biomolecular scale and will examine nanoscale biomolecular networks involved with assembly and manufacturing in biological systems (e.g., bone, shell, skin). The transfer of materials within these systems in nanofluidic biomolecular network systems will be explored. The program will exploit the fundamental principles of physical work from biological principles that derive from the investigation of the intersection between physical force dynamics of biological systems and the application of new computational and information processing tools to explore biomechanics. Further activity in this area will investigate the communication between adaptive elements within biological systems, including biofilms, as they develop in space and time, and uncovering the fundamental informational and physical architectures that underlie this unique biological property. Applications to Defense systems include the development of highly adaptive, non-linear robust systems as well as chemical and biological sensors.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

(U) Program Plans:

- Identify promising strategies in nature that allow organisms to survive under environmental extremes and adapt those strategies to other cells, tissues, organs and organisms, including platelets and red blood cells.
- Examine natural methods for inducing hypometabolic states in tissues, organs and organisms, which could lead to induced and controlled states of metabolic activity resulting in greater survival of trauma victims.
- Develop methods for selectively reducing metabolic requirements in a reversible manner following injury to extend the period from injury to initiation of treatment.
- Control cellular metabolism to reduce oxygen requirements and the needs for nutrients during extended periods following injury.
- Demonstrate and validate that cells and organisms can be engineered to respond to environmental chemicals and toxins of interest to DoD by producing signals (colors, fluorescence) that can be detected remotely.
- Transition desiccated platelets for systemic and topical applications of medical interest to the military.
- Develop approaches for engineering biofilms for a variety of DoD applications including sensing; reporting and removing agents of interest from the environment; power generation; and systematically evaluating mechanisms of biofilm induced failure in metals, welds, and fabrications methods due to corrosion.

	FY 2002	FY 2003	FY 2004	FY 2005
Nanostructure in Biology	10.508	9.370	11.000	14.000

(U) The Nanostructure in Biology program will investigate the nanostructure properties of biological materials to better understand their behavior and accelerate their exploitation for Defense applications. The tools and approaches developed under this program will also have a significant impact in a variety of critical, non-biological Defense technologies that rely on phenomena occurring at the nanoscale level. For example, the Molecular Observation, Spectroscopy, and Imaging using Cantilevers (MOSIAC) program will develop new instrumentation, computational tools and algorithms for real-time, atomic level resolution, 3D static or dynamic imaging of molecules and nanostructures. This new information about biomolecules will provide important new leads for the development of threat countermeasures, biomolecular sensors and motors, and molecular interventions to enhance and improve human performance. This tool will help with detailed knowledge of doping profiles and defects. It might be possible to use these techniques to measure and control individual atoms or spins.

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(U) Another aspect of this program will examine the use of nanostructured magnetic materials to understand and manipulate cells and tissues, enhancing their capabilities to serve as sensors and/or regulatory pathways. The Bio-Magnetics Interfacing Concepts (BioMagnetICs) program will explore nano-scale magnetism as a novel transduction mechanism for the detection, manipulation and actuation of biological function in cells and single molecules. The core technologies to be developed will focus on the many technical challenges that must be addressed in order to integrate nano-scale magnetism with biology at the cellular and molecular level, and to ultimately detect and manipulate magnetically "tagged" bio-molecules and cells. These programs will present unprecedented new opportunities to exploit a wide range of bio-functionality for a number of DoD applications including chemical and biological sensing, diagnostics and therapeutics.

(U) Program Plans:
- Demonstrate proof of concept for using nanomagnetics to detect and manipulate individual cells and biomolecules.
- Demonstrate detection of <100 electron spins using a cantilever-based magnetic resonance force microscope.
- Develop and demonstrate biocompatible, nanomagnetic tags, sensors, and tweezers that will enable magnetics based detection, manipulation, and functional control of single cells and biomolecules.
- Design and build a magnetic resonance force microscope (MRFM).
- Determine sensitivities and capabilities of the MRFM for observing single electron spins, defect profiling in semiconducting nanostructures and spin labeled protein conformations.
- Demonstrate single nuclear spin sensitivity.

	FY 2002	FY 2003	FY 2004	FY 2005
Brain Machine Interface	0.000	12.000	17.030	20.000

(U) The Brain Machine Interface program will create new technologies for augmenting human performance through the ability to access neural codes in the brain in real time and integrate them into peripheral device or system operations. This will require neuroscience and technology, significant computational efforts, and new material design and implementation. Closed-loop control of peripheral devices using brain signals will be examined. Examination of different brain regions will be accomplished in order to generate coded patterns to control peripheral devices and robotics. Techniques will be examined to extract these signals non-invasively.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

(U) Program Plans:
- Extract neural and force dynamic codes related to patterns of motor or sensory activity required for executing simple to complex motor or sensory activity (e.g., reaching, grasping, manipulating, running, walking, kicking, digging, hearing, seeing, tactile).
- Determine necessary force and sensory feedback (positional, postural, visual, acoustic, other) from a peripheral device or interface that will provide critical inputs required for closed-loop control of a working device (robotic appendage or other peripheral control device or system).
- Explore new methods, processes, and instrumentation for accessing neural codes non-invasively at appropriate spatiotemporal resolution to provide closed-loop control of a peripheral device.
- Explore new materials and device design and fabrication that embody compliance and elastic principles and capture force dynamics that integrate with neural control commands.
- Demonstrate plasticity from the neural system and from an integrated working device or system that result in real time control under relevant conditions of force perturbation and cluttered sensory environments from which tasks must be performed (e.g., recognizing and picking up a target and manipulating it).
- Implement biomimetic controllers (with robotics or other devices and systems) that integrate neural sensory or motor control integrated with force dynamic and sensory feedback from a working device or system.

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

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Information Sciences CCS-02	8.318	24.094	16.325	15.791	18.592	18.565	18.547	18.528

(U) Mission Description:

(U) This project supports scientific study and experimentation for long-term national security requirements, such as computational models and new mechanisms for performing computation and communication. This project is also exploring innovative approaches to the composition of software, exploitation of computer capability and development of novel human computer interface technologies.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Computer Exploitation and Human Collaboration	8.318	24.094	16.325	15.791

(U) The Computer Exploitation and Human Collaboration program will develop information processing technologies for users to interact with computers in an intuitive fashion, and enable collaborations as well as intelligent exchange of information in a seamless manner. Architectures for nomadic software, redesign of classical computer operating systems and secure exchange of information over insecure channels are some of the technical challenges in this area. Database currency and management of dynamically changing worldviews are the important areas of research in pervasive computing. This program will explore new man-machine interaction paradigms, based on implicit interaction where the human's intent and capability is inferred and used to drive the interaction. Research will address information overloading and simplifying user interfaces to effectively enhance warfighter performance by providing concise salient information awareness. The creation of powerful multi-agent systems and tools for effective decision-making and analysis in complex multi-participant environments will also be addressed. The technologies developed will provide radically new analysis of emergent collaborative and competitive behavior and will push the envelope of "deep" reasoning in decision making by systematically incorporating the interaction and intent. High-performance, user-centered, multimodal interfaces, which will be capable of interpreting users' combined natural communication and activity patterns, will also be developed. Overall, the program will provide vastly expanded power and improved utility, robustness and efficiency of interaction for a wide range of users, tasks and environments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2003
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) In the area of cognitive information processing, the program will develop foundations, technologies, and tools to enable the creation of robust, intelligent cognitive systems that can learn and improve over time. Among the key elements needing invention are technologies for effective, practical inferential reasoning over information of real-world complexity and uncertainty. Novel paradigms for learning from experience and for capturing episodic memories will be addressed. Difficult open questions to be researched include the integration of multiple reasoning paradigms, representation and reasoning with information that changes constantly over time, reasoning about the goals and intentions of other agents, and appropriate metrics for measuring cognitive behavior and performance.

(U) Program Plans:

- Develop techniques for exploiting episodic information learned from experience and apply that information to novel cases.
- Develop methods for combining statistical and knowledge-based learning algorithms.
- Develop high performance reasoning techniques and knowledge representation methods that handle rapid changes in information and uncertainty.
- Develop hybrid and integrated reasoning tools to overcome limitations and shortfalls in current reasoning techniques.
- Develop strategic reasoning tools to aid decision-making in multi-player contexts systematically incorporating information, incentives and goals in a distributed environment.
- Develop new forms of human-computer interaction that enable human and computers to work as synergistic teams.
- Investigate an adaptive visual and audio processing and display capability to maximize pertinent information conveyance that improves perception comprehension, retention, inference and decision-making.
- Explore cognitive models for integrating users' natural communication modalities (e.g., spoken language, gesture, and gaze) for a new class of interfaces.
- Develop adaptive multimodal processing techniques tailored to the user, task, and environment, testing their performance and usability advantages within multimodal systems developed in the program.
- Establish data-type standards for multi-modal input devices (in support of plug-and-play and system independent design).

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01				
COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Electronic Sciences ES-01	23.149	21.924	18.677	20.596	21.527	22.474	25.380	27.306

(U) Mission Description:

(U) This project seeks to continue the phenomenal progress in microelectronics innovation that has characterized the last decades by exploring and demonstrating electronic and optoelectronic devices, circuits and processing concepts that will: 1) provide new technical options for meeting the information gathering, transmission and processing required to maintain near real-time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near real-time; and 2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities. Research areas include new electronic and optoelectronic device and circuit concepts, operation of devices at higher frequency and lower power, extension of diode laser operation to new wavelength ranges relevant to military missions, development of uncooled and novel infrared detector materials for night vision and other sensor applications, development of innovative optical and electronic technologies for interconnecting modules in high performance systems, research to realize field portable electronics with reduced power requirements, and research addressing affordability and reliability. Additionally, electronically controlled microinstruments offer the possibility of nanometer-scale probing, sensing and manipulation for ultra-high density information storage “on-a-chip”, for nanometer-scale patterning, and for molecular level analysis and synthesis. These microinstruments for nanometer-scale mechanical, electrical and fluidic analysis offer new approaches to integration, testing, controlling, manipulating and manufacturing nanometer-scale structures, molecules and devices.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
University Opto-Centers	9.863	7.495	2.376	0.000

(U) This program is dedicated to coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components. Such components are critical to enhancing the effectiveness of military platforms that provide warfighter comprehensive awareness and precision engagement. Topics researched include emitters, detectors,

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modulators and switches operating from infrared to ultraviolet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules.

(U) Program Plans:

- Evaluate novel methods for the design, fabrication and demonstration of chip-scale modules that integrate photonic, electronic and MEMS based technologies.
- Characterize the impact of these new technologies on applications in the areas of bio-photonics, optically addressed memory and on-chip optical interconnects.
- Fabricate and test individual chip-level sub-assemblies for later use in prototype development.
- Design and fabricate prototype modules using the system-on-a-chip approach.
- Develop testbeds capable of fully measuring and characterizing the mixed technologies implemented in the chip-scale components.
- Evaluate the performance characteristics of the prototype modules and determine the highest payoff dual use development paths.

	FY 2002	FY 2003	FY 2004	FY 2005
Semiconductor Technology Focus Centers	5.190	12.092	8.847	5.885

(U) The Semiconductor Technology Focus Center Research program concentrates on exploratory and fundamental semiconductor research efforts that solve the most critical, long-term scaling challenges in the fabrication of high performance complex integrated circuits. This program will develop new design and fabrication approaches and will demonstrate technologies for reaching nano-scale device dimensions and hyper-scale integrated circuits that will meet future military needs.

(U) Program Plans:

- Develop efficient platform-based design methodologies and low latency interconnect technologies for complex integrated circuits that have application in high performance signal processing and communications systems.
- Develop methods for physics-based simulations of performance of deeply scaled switching device structures and circuit architectures.
- Develop the interface methodology for efficient handling and compilation of design object information for complex military integrated circuits.

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- Develop circuit architectures that reduce long interconnects.
- Develop novel device fabrication and integration approaches for deeply scaled transistors and architectures for high performance mixed signal circuits for military needs.

	FY 2002	FY 2003	FY 2004	FY 2005
Terahertz Technology	1.896	0.000	0.000	0.000

(U) This program explored technologies for a region of the electromagnetic spectrum between 0.3 THz to 10 THz, (1 millimeter to 30 micrometer) which has previously been difficult to access using conventional technologies, in order to exploit opportunities in environmental sensing, upper-atmosphere imagery, covert satellite communications and chemical and biological sensing. The goal of this effort was to realize a compact solid-state terahertz transmission and near-distance detection system with the potential for sensing and communication.

(U) Program Plans:

- Demonstrated compact sources and detectors capable to operate between 0.2 – 10 terahertz (THz).
- Demonstrated terahertz, short-range detection system.
- Assessed experimental component performance and compared against system requirements for space communications, upper-atmosphere imagery and close-operations covert communications.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Photonics Research	4.200	1.364	0.000	0.000

(U) Program Plans:

- This program continued research in photonic composites and device fabrication.

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	FY 2002	FY 2003	FY 2004	FY 2005
University Opto-Centers	0.000	0.973	0.000	0.000

(U) This program complements the University Opto-Centers program.

(U) Program Plans:

- Develop circuit fabrication and integration approaches and architectures.

	FY 2002	FY 2003	FY 2004	FY 2005
Spectrum Lab	2.000	0.000	0.000	0.000

(U) Program Plans:

- This program initiated opto-electronics, storage processing, and technology development.

	FY 2002	FY 2003	FY 2004	FY 2005
Photonics Technology Access Program	0.000	0.000	2.454	4.711

(U) Photonic Technology Access program will facilitate and enhance interaction between the developers of cutting edge photonic device technology in the industry and academic researchers that exploit these devices for novel applications. Currently, university researchers can only have access to those devices that have reached commercial stage and hence are several years behind the most advanced prototypes in functionality and performance. Industrial participants benefit by getting feedback from potential users of their device technology as well as by ensuring that the fresh graduates, who are potential employees, are trained in the latest device technologies.

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(U) Program Plans:

- Identify and enlist industrial participants.
- Develop a process for competitive selection of university participants.
- Identify a common set of photonic devices most widely used/requested and make them immediately available for experimentation.

	FY 2002	FY 2003	FY 2004	FY 2005
Supermolecular Photonics Engineering	0.000	0.000	5.000	10.000

(U) Large dendritic and other highly branched organic molecules offer great potential for active photonic applications. Three-dimensional molecular structure and shape can be engineered to orient and immobilize optically active substituents to achieve much higher electro-optic activity than with traditional polymer systems. The ability to engineer molecular structure, shape, energy transport, and chemical composition at each tier in the onion (like molecular synthesis sequence) offers the potential for distinct electronic energy level engineering without the traditional semiconductor crystal lattice. This will allow more freedom to tailor electromagnetic response of individual molecules to achieve functionality not possible in semiconductors. Potential applications include: Direct conversion of sunlight to power ("optical antenna"), inversion-less lasers and electromagnetically induced transparency (coherent organic emitters, and slow light materials), high performance photorefractive materials for signal processing and holographic memory, optical limiters and saturable absorbers as well as high performance modulators.

(U) Program Plans:

- Model and simulate advanced structures for four classes of applications.
- Improve modeling capability for predicting macro functionality from nanostructure.
- Emphasize chemical synthesis.
- Address parameters such thermal stability, environmental chemistry tolerance (O_2, H_20, etc) and photochemistry.
- Fabricate initial devices; continue modeling maturation.
- Final material synthesis, prototype device fabrications, characterization and demonstration.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01				
COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Materials Sciences MS-01	37.776	67.381	28.166	25.036	23.485	23.451	23.428	23.404

(U) Mission Description:

(U) This project provides the fundamental research that underpins the development of advanced nanoscale and bio-molecular materials, devices and electronics for DoD applications.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Nanoscale/Bio-molecular and Metamaterials	5.028	12.881	8.907	5.051

(U) The research in this thrust area exploits advances in nanoscale and bio-molecular materials, including computationally based materials science, in order to develop unique microstructures and properties of materials. This includes efforts to develop the underlying physics for the behavior of materials whose properties have been engineered at the nanoscale (Metamaterials) level.

(U) Program Plans:

- Develop theoretical understanding and modeling tools for predicting novel metamaterial structures that exhibit superior microwave and magnetic properties for DoD electric drive and propulsion, power electronics, antenna, and radar applications.
- Develop algorithmic approaches for predicting properties and structure of nano-scale and meta-materials using first principles/quantum mechanical methods with higher accuracy and reduced computational complexity.
- Couple the algorithmic approaches to methods that extract parameters for simulation of materials at larger spatial scales while conducting experiments to verify/validate the predicted properties at all spatial scales.
- Explore the mechanisms of phonon engineering for enhancing transport properties in organics.
- Develop advanced image detector materials to instantly and simultaneously detect one structural (computed tomography) and two functional (position emission tomography and single photon emission tomography) images of medical and life science interest.

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– Demonstrate materials capability to allow multimodal imaging system with two orders of magnitude increased scan speed and detection for ultra-rapid baggage screening and non-destructive testing and evaluation.

	FY 2002	FY 2003	FY 2004	FY 2005
Spin Dependent Materials and Devices	14.648	18.636	12.259	9.985

(U) The major emphasis of this thrust is to provide the theoretical and experimental underpinnings of a new class of semiconductor electronics based on spin degree of freedom of the electron, in addition to (or in place of) the charge. Not only will this class of electronics lead to novel and faster electronic devices, but it will also serve as one of the key technology enablers for quantum communications and quantum computation.

(U) Program Plans:
- Demonstrate a room temperature spin light emitting diode (spin LED).
- Demonstrate a spin transistor with significant gain.
- Demonstrate spin coherent optical devices operating at speeds approaching a terahertz.
- Demonstrate a phase coherent and phase controlled device operating above 10 GHz.
- Demonstrate a scaleable spin-based implementation for quantum logic gates.

	FY 2002	FY 2003	FY 2004	FY 2005
Engineered Bio-Molecular Nano-Devices and Systems	0.000	7.000	7.000	10.000

(U) This program seeks to develop and demonstrate engineered bio-molecular nano-scale devices that enable real time observation and analysis of bio-molecular signals thus enabling single molecule sensitivity with the simultaneous exploitation of the temporal domain (i.e., stochastic sensing). Arrays of such devices will enable an order of magnitude (10 to 100X) reduction in the time required for analysis and identification of known and unknown (engineered) molecules.

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(U) Program Plans:
- Engineer hybrid biological/inorganic device architectures that optimize compatibility and information transfer between biological and non-biological materials with single molecule sensitivity.
- Develop new and innovative technologies in the areas of device architecture, design, interconnection, fabrication and integration of organic and inorganic materials to enable measurement of time constants of single molecule events.
- Develop techniques to perform direct, dynamic, stochastic and combinatorial analysis of bio-molecular signals in order to characterize unique molecular signatures based on such analysis (i.e., automatic recognition) of various biological/chemical targets.

	FY 2002	FY 2003	FY 2004	FY 2005
Spin Electronics	15.000	15.000	0.000	0.000

(U) Program Plans:
- Explored new directions in spin electronics to determine areas important for continued DoD investment.
- Explore the benefits of using the spin degree of freedom in organic electronics.
- Study spin dynamics in nanostructures.
- Explore new materials and structures that exhibit spin dependent behavior.

	FY 2002	FY 2003	FY 2004	FY 2005
Nanotechnology Initiative	1.000	0.000	0.000	0.000

(U) Program Plans:
- Performed multidisciplinary project in nanotechnology.

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	FY 2002	FY 2003	FY 2004	FY 2005
Ultra Performance Nantechnology Center	2.100	3.000	0.000	0.000

(U) Program Plans:

- Continue efforts in ultra-performance nanotechnology and identify specific DoD targets.

	FY 2002	FY 2003	FY 2004	FY 2005
Joint Collaboration on Nanotechnology	0.000	1.800	0.000	0.000

(U) Program Plans:

- The purpose of this effort is to fund a Consortium that will investigate the potential enabling impact of recent nanotechnology material developments in biotechnology applications.

	FY 2002	FY 2003	FY 2004	FY 2005
Center for Nanostructure Materials	0.000	0.400	0.000	0.000

(U) Program Plans:

- Initiate efforts to develop novel nanostructured materials.

	FY 2002	FY 2003	FY 2004	FY 2005
Nanotechnology Research and Training Facility	0.000	2.300	0.000	0.000

(U) Program Plans:

- Initiate a new center to provide a multi-disciplinary research environment and training facility for graduate students.

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	FY 2002	FY 2003	FY 2004	FY 2005
Life Science Education and Research	0.000	5.000	0.000	0.000

(U) Program Plans:

– Explore the potential of a diverse array of multidisciplinary life science programs, ranging from molecular biology to ecology to contribute new technological capabilities for defense.

	FY 2002	FY 2003	FY 2004	FY 2005
Molecular Electronics	0.000	1.364	0.000	0.000

(U) Program Plans:

– Initiate design concepts for the integration of molecular scale electronics for molecular circuits.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, R-1 #12				
COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	349.666	409.256	404.859	479.119	561.272	625.538	691.431	701.221
Intelligent Systems and Software ST-11	88.586	50.980	43.755	43.736	55.775	74.261	81.022	77.041
High Performance and Global Scale Systems ST-19	139.101	121.242	71.047	47.566	0.000	0.000	0.000	0.000
Information Assurance and Survivability ST-24	65.204	44.892	44.459	44.898	69.474	73.283	87.855	87.768
Asymmetric Threat ST-28	56.775	77.034	79.114	80.878	91.284	107.190	119.580	119.513
Language Translation ST-29	0.000	43.432	57.201	55.883	65.767	65.945	66.196	65.826
Cognitive Systems Learning and Perception ST-30	0.000	10.595	14.822	58.846	102.743	122.139	117.140	107.272
Communications, Interaction and Cognitive Networks ST-31	0.000	29.264	42.177	54.433	56.069	49.833	58.570	58.512
Cognitive Systems Foundations ST-32	0.000	13.528	25.833	58.552	61.450	73.283	78.094	82.892
Knowledge Representation and Reasoning ST-33	0.000	18.289	26.451	34.327	58.710	59.604	82.974	102.397

(U) Mission Description:

(U) The Computing Systems and Communications Technology program element is directed toward the application of advanced, innovative computing systems and communications technologies. Cognitive Information Processing Technology will be the next revolution in computing and information processing. The technology will allow computational systems to have reasoning and learning capabilities and levels of autonomy far beyond those of today's systems. With the ability to reason, learn, and adapt, and with facilities for self-awareness, these will literally be

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systems that know what they are doing, enabling new levels of capability and powerful new applications. Encompassed in this technology push area are four new projects: Cognitive Systems Learning, Communication and Interaction Technology, Cognitive Systems Foundation, and Knowledge Representation and Computational Perception.

(U) The Intelligent Systems and Software project develops and applies new software development, processing and database management technology to produce, store, and analyze information about battle space operations. It facilitates information production by developing fundamental new techniques to transform data into descriptions of objects. It facilitates the design of complex Command, Control, Communication and Computation Intelligence, Surveillance and Reconnaissance (C4ISR) systems by formalizing descriptions of semantics, performance, and resource levels, and developing design tools to use those formalisms to assemble systems.

(U) The High Performance and Global Scale Systems project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations.

(U) The Information Assurance and Survivability project is developing the technology required to make emerging information system capabilities (such as wireless and mobile code/mobile systems) inherently secure, and to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are attacked, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites.

(U) The Asymmetric Threat project addresses one of our Nations' most serious threats. It is not the threat of a conventional, force-on-force engagement by an opposing military, but instead, the threat of an unconventional yet highly lethal attack by a loosely organized group of transnational terrorists or other factions seeking to influence U.S. policy. This new threat brings new technological challenges to the U.S. The U.S. will need to develop technology to detect, identify, classify, and track small, shadowy, hard to define and identify, and loosely organized terrorist groups as they plan adverse actions against the U.S. This new threat will have a smaller mass, exhibit fewer observables, and yet will be more lethal in consequence. Sparse activity that was once too insignificant to notice will need to be detected, correlated, and understood. This can only be achieved by developing a new level of automation to detect, correlate, and understand all of the observable evidence exhibited by these sparse events.

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(U) The newly established Language Translation project will develop and apply new software database management and human computer interaction technologies to provide fundamentally new capabilities of critical importance for a wide range of national security needs. This will enable advanced information technology to (a) automatically exploit large volumes of speech and text in multiple languages; (b) revolutionize human-computer interaction via using spoken and written English and foreign languages; (c) more effectively accomplish computing and decision-making tasks in stressful, time sensitive situations; and (d) become active, autonomous agents/assistants to the warfighter by collecting, filtering, synthesizing and presenting information in a timely and relevant form.

(U) The Cognitive Systems Learning and Perception project will develop technologies that enable systems to learn and draw on their accumulated experience by applying knowledge gained through such experience to improve performance. These technologies will lead to systems demonstrating increased self-reliance, self-adaptive reconfiguration, intelligent negotiation, cooperative behavior, and survivability with reduced human intervention. Cognitive systems will comprise three primary types of processes: reactive, deliberative and reflective. Each of these will be improved through experiential learning.

(U) The Communications, Interaction and Cognitive Networks project will dramatically improve warfighter effectiveness by developing revolutionary methods for users to interact with and direct cognitive systems (and the physical sensors and effectors they control) and for large-scale collections of cognitive systems to interact with one another in support of user objectives. Specifically, this project will develop technologies for creating systems capable of instruction, guidance, and persuasion using all forms of natural communication; technologies enabling systems to detect and assess the user's cognitive state and adapt to optimize understanding and effectiveness of the user; and high-level languages for rapid but precise specification of complex behavior in response to mission demands, such as configuration of sensor networks.

(U) The Cognitive Systems Foundations project will develop novel system-level solutions through the intelligent integration of cognitive capabilities built on robust software and hardware infrastructure. Systems with humanlike capability will integrate the cognitive capabilities of reasoning, learning, explaining, ability to be advised, self-awareness and coping robustly with surprise. These aspects of intelligence will be combined in innovative and powerful ways using new cognitive architectures. Overall this element seeks to make fundamental scientific and mathematical improvements in our understanding of and ability to create information and computing systems.

(U) The Knowledge Representation and Reasoning project is central to the creation of a new class of computational systems – Cognitive Computing Systems. These novel computer-based systems will reason, learn, and respond intelligently to things that have not been previously programmed or encountered. This will be accomplished by creating unique and powerful new abilities for computers to perceive and understand

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the world, and to reason intelligently with the results of this kind of perception. This program will develop novel and effective technologies for representing knowledge of the world in computer-processable form. This project focuses on two groundbreaking research areas that will develop core cognitive capabilities essential to a cognitive information processing system.

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

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	358.494	424.940	410.808	399.724
Current President's Budget	349.666	409.256	404.859	479.119
Total Adjustments	-8.828	-15.684	-5.949	79.395
Congressional program reductions	0.000	-16.184		
Congressional increases	0.000	+0.500		
Reprogrammings	-7.720	0.000		
SBIR/STTR transfer	-1.108	0.000		

(U) **Change Summary Explanation:**

FY 2002	Decrease reflects SBIR transfer and below threshold reprogrammings.
FY 2003	Decrease reflects congressional program and undistributed reductions, offset by an add for the Center for Critical Languages.
FY 2004	Reprioritization of Agency requirements, transfer of several programs to PE 0602702E, Project TT-13, and the net result of completing High Performance Computing programs, offset by initiation of Cognitive Information Processing efforts.
FY 2005	Expanded Agency emphasis in the new Cognitive Information Processing Technology thrust area.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Intelligent Systems and Software ST-11	88.586	50.980	43.755	43.736	55.775	74.261	81.022	77.041

(U) Mission Description:

(U) This project develops and applies new technology for software development, processing and database management for systems that produce, store, and analyze information about battlespace operations. It facilitates information production by developing fundamentally new techniques to transform signals into descriptions of battlespace entities, to exchange information about entities among different systems at both the syntactic and semantic levels, and to manage that information exchange as situations and resources change over time. These technologies lead to two payoffs. First, they accelerate the design of complex Command, Control, Communications and Computation Intelligence, Surveillance and Reconnaissance (C^4ISR) systems by formalizing descriptions of semantics, performance, and resource levels, and developing design tools to use those formalisms to assemble systems. Second, they enable field integration of legacy systems by providing general-purpose tools that use these formalisms to search for, browse, display, and combine services available to a command center, especially in coalition environments.

(U) In an effort to more accurately reflect programs by function, several programs previously budgeted in project ST-11 have shifted to other projects in PE 0602301E. The Situation Presentation and Interaction program and the Automated Speech to Text Exploitation programs are now funded in a new project entitled "Language Translation" (ST-29). Similarly, the Composable High Assurance Trusted Systems program is now funded under project ST-24.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Situation Presentation and Interaction	15.901	0.000	0.000	0.000

(U) The Communicator program created a dialog-based information interface that allows warfighters to acquire theater information, order logistical support, or obtain mission planning execution information without the need for a second human in the information loop. The dialog-based system has a scalable interface that allows the warfighter to accomplish the tasks (e.g. receive orders, resupply, identify the threat unit to their immediate front) regardless of skill level. Communicator delivered proof of concept prototypes of a dialog-based logistics ordering system

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for the USMC (logistics management at the tactical level), a maintenance assistant for F-18 ground crews at Patuxent NAS, and a shipboard command and control and status system for the USS SEA SHADOW. Further maturation of these prototypes will be accomplished in Symphony, a follow-on program to Communicator.

(U) The Babylon program is providing the tactical warfighter with real-time, face-to-face speech translation during combat and humanitarian operations in foreign territories. The program addresses domain-specific translation accuracy and response time. Early versions of Babylon technology relying on simple dictionaries and phrases have been deployed on a test basis to Afghanistan. Future versions will offer more sophisticated, flexible and fluid translation capability that will be more robust and conducive to normal human conversations.

(U) Situation Presentation and Interaction thrusts are funded in Project ST-29 beginning in FY 2003.

(U) Program Plans:

- Communicator.
  - Finalized and presented evaluation protocols and metrics for heterogeneous human computer dialog systems to the dialog and speech communities.
  - Transitioned Communicator technology to services based on proof of concept results, e.g., transition Communicator prototype to USMC for continued refinement and limited production in support of the Small Unit Logistics ACTD and the Commandants Warfighter Laboratory at Marine Corps Base Quantico.
  - Defined and published final (release) version of the Galaxy-Communicator 4.0 hub architecture for general use in the dialog systems development community.
  - Finished evaluation of commercial "smart-phone" technology vs. military-specific prototypes for cost, ruggedness, and other selection-based criteria.
  - Conducted proof of concept demonstration of Communicator technology on the USS SEA SHADOW and with F-18 maintenance crews.
  - Evaluated a follow-on research program for dialog systems.
  - Promoted standardization with the Galaxy-Communicator architecture through the World-Wide-Web-Consortium Voice Browser Group (W3C-VB).
  - Published specification of the multi-modal Galaxy-Communicator architecture.

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– Babylon.
  - -- Establish baseline hardware design for handheld translation technology.
  - -- Upgrade DARPA one-way technology to limited two-way translation.
  - -- Obtain initial software decision approvals for full-featured DARPA two-way translation.
  - -- Conduct multi-lingual data collection in Pashto, Dari, Farsi, Arabic, and Mandarin for contingency operations.
  - -- Produce prototype handheld devices for field evaluations and acceptance.
  - -- Perform initial coordination with U.S. Army PM Soldier for software integration into land warrior Block III (version 3.0).
  - -- Integrate speech recognition engines into natural language parsers and translators.
  - -- Distribute multilingual corpus to R&D community.
  - -- Deliver upgraded handhelds (capable of supporting two-way technology) to software developers.
  - -- Deliver alpha versions of DARPA two-way software for initial user testing.
  - -- Select set of foreign languages for final development.
  - -- Populate language digital resource repository at Defense Language Institute (DLI).

	FY 2002	FY 2003	FY 2004	FY 2005
Automated Speech and Text Exploitation	27.831	0.000	0.000	0.000

(U) The Translingual Information Detection, Extraction and Summarization (TIDES) program is revolutionizing the way time-critical intelligence is obtained from speech and text by developing technology to enable English-speaking operators and analysts to exploit the huge amounts of foreign speech and text available electronically but currently unexploitable due to vast volumes and insufficient foreign language skills. TIDES is creating powerful new capabilities for Detection (finding or discovering needed information), Extraction (pulling out key information), Summarization (substantially shortening what a user must read), and Translation (converting foreign language material to English). This will dramatically increase the quantity, quality, and timeliness of analysis and reporting, providing vital information to senior decision makers and enabling commanders to project U.S. power and protect U.S. forces around the globe.

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(U) The Effective Affordable Reusable Speech-To-Text (EARS) program is creating new automatic speech-to-text transcription technology whose output is substantially richer and much more accurate than currently possible. EARS will provide passive listening technology for critical languages and media for a wide range of national security applications. It will enable effective automated transcription from both broadcasts and telephone conversations.

(U) Beginning with FY 2003, Automated Speech and Text Exploitation programs are funded in project ST-29.

(U) Program Plans:

– Translingual Information Detection, Extraction and Summarization (TIDES).
  - -- Demonstrate capability to detect and track events described in English and Chinese news sources.
  - -- Create an initial capability to process Arabic text and audio sources.
  - -- Demonstrate capability to extract key information (about people, places, organizations, and relationships) from English sources.
  - -- Conduct an initial evaluation of machine translation technology.

– Effective Affordable Reusable Speech-To-Text (EARS).
  - -- Launched effort to develop automatic techniques to produce rich, readable transcripts of broadcasts and telephone conversations in English, Chinese, and Arabic.

	FY 2002	FY 2003	FY 2004	FY 2005
Software for Situational Analysis	14.026	18.313	6.055	0.000

(U) Two complementary efforts are budgeted in the Software for Situation Analysis component: Rapid Knowledge Formation (RKF), and High Precision Knowledge Formation (HPKF).

- The Rapid Knowledge Formation program enables subject matter experts who are not Artificial Intelligence experts to build, share, and reuse large knowledge bases. RKF is developing technologies that will be evaluated in challenge problem experiments in tactical ground combat. Technology challenges include direct knowledge entry by non-programmers, coordinating entry of possibly overlapping and inconsistent knowledge by geographically distributed individuals, and achieving a knowledge entry rate without AI training of twice that

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of today's AI expert, which also results in an enormous and comprehensive knowledge base (10^6 axioms). Knowledge entry R&D is focused on techniques for natural language user input into statements of logic as well as to repair and clarify knowledge base entries. Knowledge coordination focuses upon generating new axioms by such techniques as reasoning by analogy and reasoning by example, and on techniques for combining sets of axioms developed by possibly different sources into larger consistent modules. The large knowledge bases created by RKF are needed for such complex problems as the detection and identification of evasive and concealed targets, offensive and defensive information operations, and WMD capability assessments of terrorist organizations. By the end of the RKF program, a number of sets of knowledge engineering and development tools will be provided to DoD and government organizations to be incorporated into their intelligence and warfare analysis systems. The RKF technology will then enable "deeper" reasoning by intelligent system, allowing automation to support precision target identification, nomination, and engagement.

- The High Precision Knowledge Formation initiative will develop tools to build rich, complex, highly specialized knowledge bases needed to support precision tactical operations. Ground warfare tactics exhibit great variety and complexity, and depend greatly on complex relationships between natural and man-made elements of the battlefield. HPKF will develop tools to construct, maintain, and update knowledge about terrain features, mobility factors, sensor characteristics, weapons effects, and engagement tactics in combat situations ranging from desert warfare through infantry operations in jungle to urban combat. It will enable automated forces and planning systems to achieve precision engagement of hostile ground forces, both mechanized and dismounted.

(U) Program Plans:

– Rapid Knowledge Formation.
  - -- Develop very large Predictive Battlespace Awareness (PBA) knowledge bases in coordination with end users.
  - -- Provide the capability to represent KB inconsistencies and uncertainty in a manner that can be understood by subject matter experts rather than only by AI experts.
  - -- Improve reliability and operability of knowledge entry and query tools to support transition to an operational environment.

– High Precision Knowledge Formation (HPKF).
  - -- Evaluate ability of 1 mega-axiom knowledge base to support high-fidelity problem solving methods for situation awareness and tactical command and control.
  - -- Define tactical air/ground combat challenge problem, select external decision aids, and prototype export/import of knowledge with those aids.

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	FY 2002	FY 2003	FY 2004	FY 2005
DARPA Agent Markup Language (DAML)	15.856	21.760	12.000	2.594

(U) The DARPA Agent Markup Language (DAML) program is developing military software tools for use on IntelLink and other emerging collaborative Command and Control systems. The program focuses on technologies 1) to enhance interoperability, 2) to extend the reach of the World Wide Web to programs, sensors, and other data sources, and 3) to enable agent-based programs to share information through these mechanisms. DAML will develop a software language that ties the information about a web resource to machine-readable semantics (ontology), describing both data contents and service providers. DAML will be demonstrated in operational environments, including both the intelligence community (IntelLink) and control of tactical military operations. This effort will provide new technologies for the intelligent integration of information across a wide variety of heterogeneous military sources and systems in real time. In addition, its work on semantic mapping has enabled the development of a set of tools to transform existing intelligence and command/control software to operate in network-centric computing environments, using DAML ontologies and service descriptions. These tools will correlate application-specific ontologies to shared database schema, construct translators from application data structures to database schema, and build mediators that convert product streams from publishers to subscribers. The tools will be prototyped and evaluated within existing C^4ISR support systems that contain high data-rate signal processing, sensor exploitation, and engagement planning applications, and be released as a DARPA Intelligent Software Toolkit (DIST).

(U) Program Plans:

- Perform experimental analysis on and deploy IntelLink DAML Briefing and Search Tools on operational IntelLink node.
- Demonstrate and prototype DAML tools for web applications for the Military and National Intelligence Community.
- Conduct experimental analysis of DAML applications and deploy DAML tools for joint and component command and control interoperability for major commands such as Joint Forces Command (JFCOM).
- Prototype DAML tools as support to enhance the use of agents for coalition warfare command and control.
- Prototype suite of additional tools to encapsulate legacy software to support DAML ontologies, logics, and service descriptions.
- Build example mediators to convert data among DAML ontologies, referencing external knowledge bases as necessary.
- Transition DAML language Service and Rule specifications to the World Wide Web Consortium (W3C) for acceptance for commercial and civilian use.

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	FY 2002	FY 2003	FY 2004	FY 2005
Taskable Agent Software Kit (TASK)	5.617	10.907	5.490	0.000

(U) The Taskable Agent Software Kit (TASK) program will develop tools for the construction and analysis of multi-agent systems that realize a global objective through local decisions based on embedded models of the mission, the environment, and interaction with other agents. These synthesis and analysis tools will provide a sound, common engineering foundation for the development and deployment of high confidence agent-based computing solutions to a spectrum of military problems requiring robust, scalable, decentralized approaches in dynamically changing environments. While many agent-based systems are currently being built to support militarily relevant applications such as information retrieval and logistics, development methods are ad hoc and little is understood about how to engineer desirable global behaviors from local, autonomous actions and decisions or about how to mitigate and contain potentially undesirable emergent behaviors, particularly in highly dynamic and uncertain environments. This effort will explore methods derived from Control Theory, Decision Theory, and Operations Research for correctly modeling and building agent-based systems. Experiments will reveal the qualitative aspects of environments that favor the use of agent-based systems over conventional, centralized approaches.

(U) Program Plans:

- Publish initial design and analysis techniques in two focus domains: (a) control and analysis of autonomous vehicles in dynamic environments and (b) decentralized, competitive resource allocation for logistics.
- Establish a consolidated open experimental framework based on cooperative autonomous vehicles for integration and evaluation of agent control, coordination, learning, and adaptation algorithms and analysis techniques.
- Demonstrate and evaluate agent design and analysis techniques on a series of challenge problems characterized by increasing mission complexity (search to surveillance to targeting), increasing scale (10s to 100s of vehicles), and increasing environment uncertainty (dynamic target behavior to vehicle failures to malicious vehicle behavior).
- Deploy a prototype suite of integrated agent-creation tools with predictable behaviors based on mathematical techniques for modeling and analyzing agent behavior.

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	FY 2002	FY 2003	FY 2004	FY 2005
Composable High Assurance Trusted Systems (CHATS)	7.355	0.000	0.000	0.000

(U) The Composable High Assurance Trusted Systems (CHATS) program is developing the tools and technology that will enable core network services to be protected from the introduction and execution of malicious code or other attack techniques and methods. These tools and technologies will provide the security services needed to achieve comprehensive-secure, highly distributed, mission-critical information systems for the DoD. A unique feature of CHATS is that these system capabilities will be developed by engaging the open-source community in security functionality for existing open-source operating systems. Additionally, DARPA will engage the open-source community in a consortium-based approach to create a "neutral", secure operating system architecture framework. This security architecture framework will then be used to develop techniques for composing operating system capabilities to support both servers and clients in the increasing network-centric communications fabric of the DoD. In FY 2003 the CHATS program is funded under project ST-24 in this program element.

(U) Program Plan:

- Develop an operational prototype of the Composable High Assurance Trusted System.
- Develop operational capability of candidate high assurance trusted implementation language and tools.
- Validate CHATS for resistance to malicious code and other system attack techniques and methods.
- Investigate the range and alternative high value applications and services needed and required to interoperate with the composable high assurance technology.
- Develop protection profiles for the preferred applications and services.
- Investigate alternative approaches to lifecycle management for the high assurance trusted operating systems technology; identify the best alternatives.

	FY 2002	FY 2003	FY 2004	FY 2005
Automatic Target Recognition Technology	0.000	0.000	8.000	14.714

(U) The Automatic Target Recognition Technology program will develop new sensor exploitation aids to detect targets in high volume sensor data with minimal human support. It will support very large sets of targets (1000's of target types) with high identification performance and very

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low false alarm rates. It will develop modeling methods to account for target variability, caused by partial damage, design difference, or equipment loaded onto the exterior of the vehicle. The program will support interaction with humans to supply operational context, guide hypothesis development, and adapt models. By developing techniques for in-the-field training of models, signatures, and scoring parameters, it will identify vehicle-specific signatures, and develop new target fingerprinting techniques. Finally, new methods to assist humans achieve precise identification of ad hoc; poorly defined targets will be developed. The program supports rapid and accurate detection, recognition, and identification of targets in high volume sensor imagery. It will enable a dramatic reduction in sensor-to-shooter timelines, supporting dynamic target engagement. The technology objective is to make possible autonomous hunter-killer weapon concepts that will reduce manpower burdens and delays by reducing requirements for human analysis of sensor data, while dramatically increasing targeting flexibility.

(U) Program Plans:
- Obtain a regular supply of data from field and developmental sensors, covering many target types in many environmental settings.
- Obtain or estimate ground truth for those data to provide a foundation for periodic performance assessments.
- Extend existing performance analyses to provide bounds on detection, identification, and fingerprinting performance for 1000's of vehicle types, including some that cannot be modeled a priority.
- Develop model generation, model update, detection, recognition, identification, and fingerprinting algorithms based on a range of technical approaches.
- Periodically assess technologies on the field data, computing statistically significant estimates of performance to compare against the performance analyses.

	FY 2002	FY 2003	FY 2004	FY 2005
Information Dissemination and Management	0.000	0.000	6.210	14.714

(U) The Information Dissemination and Management Program develop technology to allocate information resources (transmission, storage, and processing) for optimal utilization of data across multiple missions. Techniques will be developed that will adjust information flows to fit available bandwidth/time for bulk data such as target imagery (by adjusting quality, data rate, and time of transmission), streaming data, such as video, GMTI (by adjusting quality and rate) and command data, such as waypoints, events (by adjusting time of transmission). The program will explore approaches to the reallocation of resources dynamically as tasks arise and network topology and capabilities change, through the use of intermediate storage or intermediate processes (e.g. registration). The program provides real-time sensor-to-shooter resource management to support dynamic operations, including targeting, force protection, and battlespace awareness. Most importantly it will provide information for use

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by commanders and weapons when communications resources are oversubscribed during battle conditions, and provide the means to respond in real-time to changes in resources due to outages or battle damage.

(U) Program Plans:
- Work with service partners to identify and obtain a suitable testbed, with supporting data links, databases, application servers, and users.
- Define an information architecture that establishes insertion constraints for information management technology.
- Develop and extend real-time resource allocation technology to manage network assets in response to time-varying demands.
- Develop human interfaces to allow controllers to specify information needs and anticipate future demands.
- Insert information management algorithms into the testbed, and stimulate them with increasing levels of subscription.

	FY 2002	FY 2003	FY 2004	FY 2005
Rapid Software Composition for Embedded Systems	0.000	0.000	6.000	11.714

(U) The Rapid Software Composition for Embedded Systems program develops technology to permit rapid assembly of heterogeneous C^4ISR components for execution on complex, highly parallel real time embedded architectures. It will explore techniques to permit rapid parallel code development and optimization to leverage advanced architectures for development, exploration and rapid deployment of C^4ISR components. This program will provide tools and software libraries that allow C^4ISR systems to be rapidly assembled from discrete, protested components. It will assist developers tailor C^4ISR systems to be assembled for mission-specific tasks. In addition, the technology will facilitate mapping C^4ISR system components onto advanced run time architectures for high performance operations in limited footprint environments (airborne, tactical vehicle, afloat). Its tools will rapidly develop and optimize new C^4ISR capabilities using spiral development processes without loss of performance.

(U) Program Plans:
- Identify a set of challenge applications across the spectrum of C^4ISR missions.
- Assemble a library of kernal algorithm components.
- Map the kernels onto representative hardware architectures.
- Develop input/output/state descriptions of each kernel, as mapped to each architecture.

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- Construct tools to assemble kernels into systems, including data flows and process/processor assignments.
- Build predictive models of systems assembled from kernels to verify run-time feasibility and achievement of desired performance.
- Validate the tools and models within the challenge applications.

	FY 2002	FY 2003	FY 2004	FY 2005
Reuse Technology Adoption Program (RTAP)	2.000	0.000	0.000	0.000

(U) The Reuse Technology Adoption Program (RTAP) focused on research strategies for multi-agent system technology and transition results to accomplish software reuse.

(U) Program Plans:
- Explored peer-to-peer communication models in context of military requirements.
- Experimented with technologies for developing/evolving coalitions of software components.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA2 Applied Research	Computing Systems and Communications Technology PE 0602301E, Project ST-19

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
High Performance and Global Scale Systems ST-19	139.101	121.242	71.047	47.566	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) This project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations. The project is comprised of six primary components - - Networking, Responsive Computing Architectures, Network Embedded Technology, Autonomous Systems Control and Augmented Cognition and Mixed Initiative Control of Automa-Teams.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Networking	33.685	6.100	0.000	0.000

(U) The Networking programs are developing new paradigms in networking technologies to meet future defense and national security needs. The objective of the overall effort is to create highly robust and rapidly configurable networking capabilities essential for both secure national infrastructure and ad-hoc military networks through key innovations in software and hardware technologies. The results will be applicable to wired, wireless and mixed networks. The Networking component is comprised of Network Modeling and Simulation, Active Networks and Ultra High-Performance Networking.

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- The Network Modeling and Simulations program will develop tools to address the challenge of predicting the end-to-end and internal behavior of complex networks over a broad range of time scales, network sizes and composition. New models and simulators will enable reliable and rapid planning, design, analysis and configuration of military and emergency networks with minimal manual intervention. This program is funded under project ST-31 in FY 2003.

- The Active Networks program investigates the use of smart packet processing to enable new strategies in rapid network service introduction and enhancement. Active network-based authentication mechanisms will enable highly dynamic access control not possible with today's IP infrastructure.

- The Ultra High-Performance Networking program is advancing transparent all-optical networking and gigabit wireless techniques to dramatically enhance bandwidths available to end-applications. Gigabit end-speeds are essential for a multitude of defense applications involving distributed processing of sensor outputs. All-optical self-healing architectures are also being developed as a part of a concerted effort to create high-confidence networking infrastructures. New paradigms in wireless link techniques are also being explored to make possible robust networking in complex, harsh environments.

(U) Program Plans:

- Network Modeling and Simulation.
  - Implement a scalable, measurement driven packet level parallel simulation achieving high-level architecture compliance, and 10-fold increase in speed over conventional sequential simulation.
  - Develop mathematical models of end-end and internal network performance.
  - Demonstrate prediction in DoD networks with fifty nodes.

- Active Networks.
  - Develop and demonstrate: 1) Intrusion Detection and Response (IDR) prototype; 2) Active Network Operating System focused on policy-free security architecture and availability; and 3) the capability to operate within a mobile computing environment.
  - Develop active network techniques for distributed network management, resource control, and distributed network service deployment, configuration, and management.

- Ultra High-Performance Networking.
  - Demonstrate correlation of multi-gigabit per second transfer of radar signal streams from multiple sources.

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-- Demonstrate 16-32 video blanket media streams and client side browsers for display of these streams.
-- Design precision (1cm) network based geo-location system scalable to 100 nodes in an indoor setting.
-- Demonstrate hybrid optical/radio frequency self-healing link with proactive switching at 600 Mbps.

	FY 2002	FY 2003	FY 2004	FY 2005
Responsive Computing Architectures	27.756	59.276	55.712	47.566

(U) The Responsive Computing Architectures component is bringing needed flexibility to DoD systems. It is developing integrated computing subsystems that will respond in real-time to dramatic changes in mission application requirements and operating constraints based on the mission-of-the-day. The current projects are focused on energy/power management, quality of service, and algorithm/application computing diversity and scalable computing efficiency. This technology has direct and significant impact for military systems such as the Land Warrior/Objective Force, ground and airborne autonomous devices, distributed sensors, space sensors, and intelligence collection ground systems. The Responsive Computing Architecture component is comprised of Power Aware Computing and Communications, High Productivity Computing Systems, Thermodynamics of Randomized Computing and Network-Centric Infrastructure for Command, Control and Intelligence.

- The Power Aware Computing and Communications (PAC/C) program is developing an integrated software/hardware power management technology suite comprised of novel techniques that may be applied at all levels of a system from the chip to the system level. Embedded military computing systems such as future Land Warrior systems, autonomous devices, distributed sensors, and space sensors have extreme dynamic computational and energy requirements. PAC/C will enable embedded computing systems to reduce energy requirements by ten to one hundred-fold for energy constrained military applications ranging from hand-held computing devices to unmanned aerial vehicles.

- The High Productivity Computing Systems (HPCS) program will provide DoD with significant technology and capability advancements for the national security and industrial user communities by filling a high-end tera to petascale computing gap between today's late 1980's based technology High Performance Computing systems and the promise of quantum computing. This program is targeting high end computing, medium to long term, national security missions where U.S. superiority and security is threatened, according to two recent DoD studies. The proposed technology development plan is part of a three-phase program that will extend up to the end of this decade. The three phases are concept study, research and development, and full-scale development. HPCS will address a number of critical technology barriers over the next decade: (1) processor/bandwidth performance efficiency; (2) software availability/reliability of large

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scale computing systems; (3) integral hardware, software, application robustness; (4) intrusion resistance; (5) run-time software brittleness; (6) time-to-solution; and (7) cost of developing, operating, and maintaining DoD national security applications. As an example, performance (efficiency) for critical national security applications will be improved by 10-to-40 fold. Early identification of high-end computing application computing requirements, metrics, and performance prediction tools will be used throughout the program to assess both technical and schedule progress.

- The Thermodynamics of Randomized Computing program is a revolutionary approach to energy reduction based on the fact that randomized algorithms, because of their associated error probability, allow computing with greater uncertainty or (thermodynamic entropy than corresponding deterministic algorithms) and hence consume less energy. This program will provide an early proof-of-concept of the proposed novel idea from an energy perspective.

- The Network-Centric Infrastructure for Command, Control and Intelligence program is developing technologies to automatically create virtual work centers, called "habitats," that can bring together the right combination of people, computer systems, robots, and data to accomplish a specific set of tasks. These habitats can be dynamically reconfigured because they are "aware" of the interrelated combat conditions and the context of the environment. New technologies will be developed to allow the warfighter, at any level of command, to rapidly assemble a habitat that addresses the needs of a specific task e.g., geographic situation awareness, or command interfacing with coalitions. This program moves to ST-32 in FY 2003.

(U) Program Plans:

– Power Aware Computing and Communications.
  - -- Demonstrate 10X power/energy aware reduction techniques across five power aware levels: 1) mission, 2) subsystem/algorithm, 3) software/compilation, 4) operating systems, 5) architecture/devices into the power aware simulator library.
  - -- Conduct preliminary PAC/C energy simulation/modeling framework concept demonstration.
  - -- Provide a beta release of the PAC/C energy aware simulator and modeling framework for the PAC/C subscale developers to evaluate.
  - -- Finalize selection of the power aware technologies to be incorporated and demonstrated for each of the planned power aware subscale demonstration projects which include the following application areas: distributed sensors, space processing, Land Warrior/Objective Force, and communications.
  - -- Continue the development of the final subscale demonstration projects and provide interim and final demonstrations.

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– High Productivity Computing Systems.
  - -- Perform an industry concept and critical technology assessment review for viable HPCS systems for potential implementation in the (2007 - 2009) timeframe.
  - -- Release alpha "value-based" productivity metrics and benchmarks to guide future program research and development activities.
  - -- Address large system brittleness by exploring hardware and software reliability/fault tolerance capabilities, active application software bug tolerance, and intrusion identification and resistance.
  - -- Explore balanced "productive" system architectures balancing processors, memory, interconnects, software, and programming environments.
  - -- Downselect viable system solutions and critical technologies to be prototyped; demonstrated and evaluated prior to full-scale implementation.

– Thermodynamics of Randomized Computing.
  - -- Establish the feasibility of using randomized algorithms to save energy via entropy management.
  - -- Define the computing model and demonstrate the thermodynamic behavior of randomized algorithms.
  - -- Implement in silicon the critical concepts of randomized computing.

– Network-Centric Infrastructure for Command, Control and Intelligence.
  - -- Develop Joint Service experimental plans.
  - -- Conduct studies to assess the ability of emerging COTS infrastructure technologies to support habitat construction, evolution, and interaction.

	FY 2002	FY 2003	FY 2004	FY 2005
Network Embedded Technology	24.215	33.187	15.335	0.000

(U) The Network Embedded Technology component will develop software technology to build distributed, real-time, and embedded applications, ranging from tens of computing nodes to over a million. Each program is driven by carefully selected Open Experimental Platforms to facilitate the continuous evaluation of progress and end-user influence. By using major theoretical breakthroughs during the past decade in hybrid systems, statistical physics, finite-size scaling, generative programming, and distributed control, the programs have solid foundation to

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achieve the ultimate goal of revolutionizing how software-intensive embedded platforms are built for the DoD. The Network Embedded Technology component is comprised of Networked Embedded Systems Technology and Program Composition for Embedded Systems.

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

- The Programmable Composition of Embedded Software (PCES) program is developing technology to support faster, more reliable development of distributed embedded software for intelligent systems. This technology will enable programmers to safely and productively integrate so-called "cross-cutting" aspects, such as concurrency, synchronization, security, and memory management; along with the core functionality that implements intelligent software interaction with a diverse suite of sensors and actuators in real time. The reusable code-base, tools and reference applications being delivered by PCES leverage human effort to rapidly produce higher-quality, more adaptable software. PCES technologies are assuring that the resulting software achieves required properties and can enable the production of the next generation of high-confidence military systems that depend fundamentally on robust and efficient software operation.

(U) Program Plans:

– Network Embedded Systems Technology.
  - -- Design deterministic and probabilistic methods for self-stabilizing protocols for lightweight coordination services such as global clock synchronization, sensor localization, etc.
  - -- Conduct experimental and theoretical investigations on *phase-transition* effects (i.e., the dramatic changes from being easy to becoming intractable, in problems that involve the simultaneous satisfaction of multiple constraints).
  - -- Investigate design approaches for the customization of coordination-services to specific applications.
  - -- Develop formal modeling and verification techniques for coordination-services and for integrating them.
  - -- Develop low-cost, Open Experimental Platforms for network embedded software technology.
  - -- Conduct baseline demonstrations of NEST technology in a variety of environmental monitoring and tracking applications.

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-- 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 customizable and adaptable solutions for coordination-services for network embedded software technology applications.
-- Develop tools for the automatic composition and verification of application specific coordination service packages.
-- Demonstrate the synthesis of an optimized coordination service package on the experimental platform.
-- Demonstrate the application design process and evaluate performance of a deployed thousand node sensor system capable of self-initialization, detecting, tracking and assisting in the pursuit of smart evaders.

– Program Composition for Embedded Software (PCES).
-- Develop scalable techniques for incremental formal validation and optimization of embedded software.
-- Develop language representation and compiler techniques for aspect-oriented programming of fine-grained and coarse-grained aspect-oriented programming of embedded systems.
-- Develop software analysis and composition tools that can reason about the complex interactions and tradeoffs among cross-cutting systemic aspects to enable safe code composition and manipulation that avoid multi-aspect interference.
-- Develop suites of reusable aspect software that implement cross-cutting systemic properties and mechanisms in a form suitable for composition by the automated analysis and composition tools.
-- Develop open standards-based model-driven tools and representations for generating, optimizing, and configuring component-oriented embedded system middleware and applications during various binding times, ranging from compile-time to run-time.
-- Develop quality-of-service enabled distributed services for persistence, fault tolerance, scheduling, and multi-media sensor data transmission.
-- Develop catalogs of patterns and pattern languages that formalize the successful techniques and constraints associated with developing and validating aspect-oriented embedded systems middleware and applications.
-- Develop open experimentation platforms that PCES technology developers and DoD system integrators can use to prototype and systematically evaluate PCES technology capabilities to prosecute time-critical targets in operational avionics and unmanned air vehicle systems.
-- Demonstrate control services for multi-media sensor data, pair-wise interacting aspects, transformation strategies, and program composition services for coordinated operations between manned/unmanned air vehicles and command and control centers.
-- Develop interacting aspects, transformation strategies, and program composition services for coordinated operations between manned/unmanned air vehicles and command and control centers.

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	FY 2002	FY 2003	FY 2004	FY 2005
Autonomous Systems Control	24.237	6.001	0.000	0.000

(U) The Autonomous Systems Control component will develop the tools necessary to deploy, control and coordinate the full spectrum of autonomous system resources effectively and efficiently in order to ensure mission success. DoD systems are rapidly becoming hybrids, incorporating both humans and autonomous system components such as robots and software agents; developing the software to achieve that integration is the subject of this component. The Autonomous Systems Control component is comprised of Autonomous Negotiation Teams and Autonomous Software for Learning Perception & Control.

- The Autonomous Negotiation Teams program is developing the software technology to resolve time-critical constraints in logistics and mission planning. The resource management problem is being solved via the interaction of lightweight, mobile software components using a bottom-up organization approach and negotiation as techniques for resolving ambiguities and conflicts. The technology enables designers to build systems that operate effectively in highly decentralized environments, making maximum use of local information, providing solutions that are both good enough, and soon enough.

- The Autonomous Software for Learning Perception and Control program will program autonomous mobile robots to independently perform a variety of military tasks in a diverse spectrum of complex, dynamic environments. The goal is to achieve validated performance at near-human levels in a full range of real-world environments for perception-based autonomous vehicle driving/navigation and effective interaction of robots with humans. This program is pursuing several alternative approaches to augment pre-programmed activities and responses with powerful learning-derived competencies for perception and control analogous to those of biological systems. In other words, this software will enable autonomous systems to modify their behavior in response to real-world situations or barriers. Integrated perception, including fusion of data from multiple sensor and multiple processing modalities of the same data will reduce operator intervention and achieve semi-autonomous operation. The result will be highly capable robots that can learn new tasks and adapt quickly to new environments with minimal programming effort, with numerous applications in the battle space of the future. This program is funded under project ST-33 in FY 2003.

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(U) Program Plans:

– Autonomous Negotiation Teams.
  - -- Demonstrate ability to identify autonomous negotiating teams needed for cooperative flight scheduling and maintenance planning.
  - -- Demonstrate prototype implementation and evaluation of negotiation in real-time mission planning for Harrier aircraft mission planning and maintenance operations.
  - -- Demonstrate ability for hierarchical coalition formation in real-time and avoidance of conflict by changing plans.
  - -- Demonstrate an integrated utility for the selection of negotiation strategies to meet goals of convergence, optimality, timeliness and stability in changing environments.
  - -- Demonstrate dynamic re-synthesis of the application under time limit using distributed constraint solvers.

– Autonomous Software for Learning Perception and Control.
  - -- Demonstrate behavior scalability and reuse; learning compatible knowledge representations; and task-based, sensor data exploitation.
  - -- Identify metrics for evaluation and associated evaluation methodologies.

	FY 2002	FY 2003	FY 2004	FY 2005
Augmented Cognition	12.771	0.000	0.000	0.000

(U) The Augmented Cognition component focuses on developing technologies to augment the warfighter's cognitive capacity and capabilities. This is a new research area designed to significantly expand human capability by augmenting human cognition and performance in the way that weapons, vehicles and sensors significantly extend human capabilities. The hypothesis of this emerging field is that the impressive progress in neural science, computation and miniaturization can now be leveraged to enable new concepts of warfare. The Augmented Cognition component contains two efforts: Augmented Cognition and the Perceptual Processing Display program.

- The Augmented Cognition (AugCog) program will develop the means to measure a subject's cognitive state in real time and then manipulate that state in order to greatly improve the performance of various functions in the human machine interface paradigm. The goal of the Augmented Cognition program is to develop the technology to integrate new digital devices that support memory, perception, and thinking, and link that support with the user's context state information to directly improve the overall cognitive performance of the warfighter in complex and operationally stressful conditions. The program will culminate in the development of a closed-loop human-

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computer interaction capability with the computer able to anticipate, predict, and augment the performance of the user. This program is funded under project ST-31 in FY 2003.

- The Perceptual Processing Display program studied advances in neuroscience and perceptual processing technologies to develop new and redesigned devices that deliver information to the human perceptual system. Technologies were explored to simplify relevant and eliminate irrelevant information that will lead to improved perception, comprehension, memory, inference, and decision-making.

(U) Program Plans:

– Augmented Cognition.
  - -- Develop and evaluate non-invasive, real-time, cognitive state detection technology for measuring the cognitive processing state of the user.
  - -- Develop new Functional Optical Imaging sensor system technical approaches based on Near Infra-Red and validate the technologies as a means to monitor prefrontal cortex activity.
  - -- Establish and implement cognitive relaxed computer dialog architecture to support the warfighter in natural language interface with the computer.

– Perceptual Processing Displays.
  - -- Determined optimal methodologies and technologies to expand and exploit the perceptual-cognitive processing bandwidth.
  - -- Evaluated technologies to enhance the color, luminance range, sharpness, contrast, and motion sensitivity to match human capabilities not exploited by conventional display systems.

	FY 2002	FY 2003	FY 2004	FY 2005
Mixed Initiative Control of Automa-Teams (MICA)	10.526	16.678	0.000	0.000

(U) The Mixed Initiative Control of Automa-teams (MICA) program is developing algorithms, software, modeling and simulation capabilities to perform multi-level planning, assessment and control of distributed, autonomous combat forces. MICA will provide a commander 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

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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. In FY 2004 and beyond, this program will be funded in PE 0602702E, Project TT-13.

(U) Program Plans:

- Develop algorithms and software to assign autonomous combat vehicles to task-oriented teams and to assign mission-derived subtasks and generate events schedules and collaborative routes to each combat vehicle in a team.
- 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 second phase open experimental simulation environment, driven by suppression of fixed and mobile air defense elements, time sensitive targets, and incorporating multiple UAV teams and multiple command levels.

	FY 2002	FY 2003	FY 2004	FY 2005
Data Intensive Systems	2.311	0.000	0.000	0.000

(U) The Data Intensive Systems component developed new hardware, software, and algorithmic approaches to computer memory organization and access that eliminated severe bottlenecks in present designs. Many defense applications such as dynamic, sensor-based processing, battlefield data-processing integration, and high-speed cryptographic analysis are data-starved, that is to say, the processor is so fast that it has to wait for memory to be accessed from RAM between operations thus slowing down the computation. This program developed innovative data access techniques to solve this problem and enable new military capabilities with high rate sensor data streams and irregular data base memory access requirements.

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(U) Program Plans:
- Incorporated additional floating point capability to a PIM chip.
- Demonstrated PIM technology in place of a conventional memory module to act as an intelligent memory module capable of performing data intensive computing.

	FY 2002	FY 2003	FY 2004	FY 2005
System Engineering for Miniature Devices	2.600	0.000	0.000	0.000

(U) The Systems Engineering for Miniature Devices research project focused on the integration of existing/emerging technologies in the areas of mobility, power, sensing, actuation, communication, and computation, with a special focus on the software issues involved in controlling and programming these devices.

(U) Program Plans:
- Conducted system engineering for mini devices effort.

	FY 2002	FY 2003	FY 2004	FY 2005
Secure and Dependable Software	1.000	0.000	0.000	0.000

(U) The Secure and Dependable Software Program developed technologies to enable production of secure and dependable software for Military's mission-critical applications. It addressed the need for cost-effective technological tools to monitor, assess, analyze and predict threats and risks.

(U) Program Plans:
- Developed specific tasks for mobile agents in forensic analysis and risk assessment.
- Mapped the strategies and behaviors of mobile agents for gathering information, investigating events and activities and assessing data for compliance with known standards and controls.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Information Assurance and Survivability ST-24	65.204	44.892	44.459	44.898	69.474	73.283	87.855	87.768

(U) Mission Description:

(U) This project is developing the technology required to make emerging information system capabilities (such as wireless and mobile code/mobile systems) inherently secure, and to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are attacked, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites. Technologies developed under this project will be exploited by all the projects within this program element, and by the Command and Control Information Systems (Project CCC-01, PE 0603760E), Information Integration Systems (Project CCC-02, PE 0603760E), and other programs that satisfy defense requirements for secure and survivable systems.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Fault Tolerant Networks	34.622	15.235	3.000	0.000

(U) The Fault Tolerant Networks (FTN) program will develop technologies to provide continuous and correct network operation even when attacks are successful. These technologies will reduce the amount of damage sustained during an attack, allowing networks to maintain an acceptable, minimum level of functionality. Technologies for strengthening networks will be developed by introducing fault tolerance capabilities against possible attacks at the network level, emphasizing integrity and availability; and technologies for mitigating potential vulnerabilities associated with denial of service attacks. The most promising of these technologies will be tested in operationally relevant experiments with U.S. warfighters in DARPA's Partners in Experimentation program, which is also budgeted in this project.

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(U) Program Plans:

- Demonstrate Source Path Isolation Engine experimentation using Collaborative Advance Interagency Research Network and commercial-off-the-shelf intrusion detection systems to show the trace of an attack back to its ingress point soon after attack.
- Develop capability to provide detection of denial of service attacks on the Quality of Service data flow and to isolate the attacking packet streams using the concept of congestion pricing in resource reservation, the security of resource reservation will be enhanced against insider router attacks.
- Demonstrate a scalable architecture and localized optimization algorithms for constructing a dynamic, topologically sensitive root context for any network topology, thus, removing the dependence of a single, fixed root content for the domain name server.
- Explore traffic modeling techniques for traffic analysis and for countermeasures to denial of service attacks in wired and wireless networks; develop a tool set that provides survivable real-time communication services.
- Design new, efficient algorithms for detecting attacks and faults in optical networks, including models and algorithms for cost-based approaches to reserving routes and bandwidth in anticipation of attacks and faults.
- Develop onion routing system, a virtual overlay network for resilience to traffic analysis in operational field use.
- Develop a distributed, scalable, reliable, and cost-effective architecture for an active network router that schedules node resources and dynamically reconfigures itself in response to failures.
- Design and develop modifications to Source-initiated Ad-hoc Routing Algorithm to incorporate techniques for intrusion-resistant mechanisms for Flow-based Route Access Control, multi-path routing, and flow monitoring algorithms.
- Develop mobile distributed firewall architectures to allow rapid deployment of mobile networks with full enclave protection.
- Provide public key infrastructure support for rapid revocation of individuals, to include terminal exclusion and network reconfiguration.

	FY 2002	FY 2003	FY 2004	FY 2005
Dynamic Coalitions	9.898	10.618	2.009	2.000

(U) The Dynamic Coalitions program is developing technologies to support the secure creation of dynamic coalitions including the necessary technologies for policy management, group communications, supporting security infrastructure services, data sharing, and joint collaboration spaces. These areas are critical for future warfighting scenarios as outlined by Joint Vision 2020, which states that future military operations will

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be increasingly conducted jointly, both with multiple branches of the U.S. Armed Forces and with allied and coalition forces, requiring increased levels of interoperability. Further, this effort will build upon recent advancements in wireless networking technologies by investigating technologies to migrate coalition information assurance tools from servers to gateway radios thus placing the functionality directly at the interface, and localizing coalition policy to gateways. The most promising technologies developed under this program will be tested in operationally relevant experiments with U.S. warfighters in DARPA's Partners in Experimentation program, which is also budgeted in this project.

(U) Program Plans:

- Develop extensions to team-based access controls addressing dynamic coalition membership and coalition missions, access to coalition resources at the task level, and modeling the use of self-limiting resource permissions that evolve with the state of mission-oriented tasks.
- Develop algorithms that will remove dynamic group management bottlenecks by replacement of public-key techniques with much faster secret-key techniques, insertion of computational shortcuts, and potentially, the replacement of cryptography with secret-sharing techniques (for additional performance gains).
- Develop and demonstrate several intra-domain group key management approaches for mobile subscribers, built around a decentralized, hierarchical architecture: one approach based on current Internet Engineering Task Force (IETF) IPSec multicast key management proposal; a second using same approach modulated by a hysteresis interval for environments with unreliable connectivity; a third using explicit handoff of security associations among key distributors; and finally, an approach using periodic re-keying.
- Develop a general framework for hierarchical access control, decoupling rights authorization from information and service access, resulting in enhanced coalition scalability.
- Design, develop and integrate new certificate cache architectures with secure group communication system.
- Develop a cryptographic hardware accelerator to speed up cryptographic computations for devices used in coalition networks.
- Demonstrate integrated facilities for transitive delegation, with support for capacity sandboxing, reverse sandboxing, and object caching.
- Develop and demonstrate intra-domain group key management protocols extended to handle mobile key distributors within mobile networks.
- Develop a modular architecture and robust key agreement within a dynamic coalition, including reconfigurability and evaluation.

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	FY 2002	FY 2003	FY 2004	FY 2005
Cyber Panel	10.745	4.155	1.000	0.000

(U) The Cyber Panel Program is developing capabilities to help defend mission-critical information systems by monitoring them for signs of cyber attack, and allowing operators to manage the operation of system security and survivability features to avert or counter developing attack situations. Intrusion assessment technologies are being developed to detect security threats through correlation and analysis of observed/reported activities. Autonomic response capabilities are being developed to react in milliseconds to block or withstand many classes of known and unknown attacks. Monitoring and response components are being developed that allow warfighters to observe the performance, health and threat state of mission critical information systems, project the likely impact of reported cyber attacks on system operation, assess possible defensive actions, and carry them out. The Cyber Panel program will help reduce the vulnerability of military systems to strategic cyber attacks by creating technologies that enable human-directed command and control over cyber resources, operationally relevant cyber situational understanding, mission impact assessment, and defensive response evaluation and execution. The most promising of these technologies will be tested in operationally relevant experiments with U.S. warfighters in DARPA's Partners in Experimentation program, which is also budgeted in this project.

(U) Program Plans:

- Investigate methods for augmenting passive intrusion detection sensors with capabilities to actively probe for additional attack information.
- Explore techniques for improving the effectiveness of auto-response defenses with limited intelligence about attack models.
- Experiment to determine the usability of general-purpose anomaly detection algorithms to monitor a large, complex military software system.
- Combine selected Cyber Panel technologies into an integrated demonstration prototype incorporating cyber attack detection, correlation, assessment, and response capabilities.

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	FY 2002	FY 2003	FY 2004	FY 2005
Partners in Experimentation	9.939	4.544	6.044	0.000

(U) The Partners in Experimentation program will conduct security technology experimentation with operational military and coalition partners. Operational experimentation will provide valuable feedback to the security technology research and development process which will demonstrate to operational personnel the benefits of advanced technology, and accelerate technology transition.

(U) Program plans:

- Convert intrusion assessment algorithms into data reduction tools for military computer intrusion detection analysts.
- Demonstrate situational awareness and interactive "big-board" control of broadly distributed security technologies, including scalable host based defenses, in military operational environment.
- Demonstrate large-scale hardened client technology and policy implementation in military operational environment.
- Evaluate performance and scalability of lab proven anomaly detection techniques for intrusion detection in real world high volume environments.

	FY 2002	FY 2003	FY 2004	FY 2005
Composable High Assurance Trusted Systems (CHATS)	0.000	4.340	4.017	0.000

(U) The Composable High Assurance Trusted Systems (CHATS) program is developing the tools and technology that enable the core network services to be protected from the introduction and execution of malicious code or other attack techniques and methods. These tools and technologies will provide the high assurance, trusted operating systems context/basis to host the planned security services needed to achieve comprehensive-secure, highly distributed, mission-critical information systems for the DoD. This project will fundamentally change the existing approach to development and acquisition of high assurance trusted operating systems technology. These trusted operating system capabilities will be developed by engaging the open-source community in security functionality for existing open-source operating systems. Additionally, DARPA will engage the open-source community in a consortium-based approach to create a "neutral", secure operating system architecture framework. This security architecture framework will then be used to develop techniques for composing operating system capabilities to support both servers

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and clients in the increasing network-centric communications fabric of the DoD. These technologies are critical for defensive information warfare capabilities and are needed to ensure that DoD systems of the future are protected from imminent attack. This program was originally funded in this PE under Project ST-11 in FY 2002 and prior.

(U) Program Plans:
- Implement prototype adaptations of the preferred applications and services as indicated by the protection profiles.
- Implement the composable high assurance trusted system and the adapted applications and services on candidate representative DoD mission critical system server fabric.
- Investigate alternative approaches for extending the composable high assurance technology to the network client fabric.
- Develop protection profiles for the best candidate high assurance client side trusted systems.
- Implement the best of the lifecycle support alternatives.
- Investigate the alternative technology transfer options that provide the best long term persistence and continuity for the CHATS technology and tools.

	FY 2002	FY 2003	FY 2004	FY 2005
Next Generation Optical Networks	0.000	2.000	8.671	14.486

(U) The Next Generation Optical Networks program will revolutionize the operation, performance, security, and survivability of the United States' critical inter-networking system by leveraging technology developed in DARPA photonics component and secure networking programs. These goals will be accomplished through a transformation in fundamental networking concepts that form the foundation upon which future internetworking hardware, architecture, protocols and applications will be built. Key technical enablers that will be developed in this thrust include: the elimination of data flow bottlenecks through the creation of optical network hardware that minimizes the occurrence of optical-to-electrical-to-optical conversions, network management tools that guarantee optimization of high density optical channels such as those provided by wavelength division multiplexing, the creation of a new class of protocols that permit the cross-layer communications needed to support quality-of-service requirements of high priority national defense applications, and novel concepts in intelligent and cognitive switched based networks. Integration of terrestrial fiber optic lines with free-space optical and RF wireless transport systems, and establishment of a CONUS wide testbed with mobile overseas nodes will enable development, experimentation, and validation of new hardware, software, and network

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architecture concepts. This effort will deliver the high-performance internetworking capabilities needed for development of applications such as distributed and network based command and control, intelligence analysis, predictive logistics management, simulation and scenario enhanced decision-making support for real-time combat operations, and assured operation of critical U.S. networking functions when faced with severe physical layer attack. These network-based functions will support the real-time, fast-reaction operations of senior leadership, major commands and field units. In addition, the insertion of optical networking technologies within highly integrated weapon system platforms, such as tactical aircraft, will be investigated as possible upgrades to current platforms and future platform designs.

(U) Program Plans:
- All-optical hardware design and fabrication, regeneration and optical wavelength switching enabled.
- Network data flow/bottleneck analysis, 10 Gb/s to end user.
- Switch architecture design for zero apparent jitter real-time applications.
- National testbed hardware specification, local area to wide area network integration, with data-format independence.
- Protocol development for physical layer-to-application layer connectivity.
- Analyze optical technologies for use in highly integrated weapon platforms to determine suitability for upgrades and future designs.

	FY 2002	FY 2003	FY 2004	FY 2005
Malicious Code Analysis Program	0.000	2.000	9.859	14.807

(U) The goal of the malicious code analysis program is to develop dynamic quarantine defenses for U.S. military networks against large-scale malicious code attacks such as computer-based worms. The ever-growing sophistication of the malicious code threat has surpassed the ability of commercial industry to address this problem. As the U.S. military pushes forward with network-centric warfare, terrorists and other nation-states are likely to develop and employ malicious code to impede our ability to fight efficiently and effectively. This program will develop the capability to automatically detect and respond to worm-based attacks against military networks, provide advanced warning to other DoD enterprise networks, study and determine the worm's propagation and epidemiology, and provide off-line rapid response forensic analysis of malicious code to identify its capabilities, modalities, and future behavior. Technical approaches include the development of a hybrid/hierarchical/distributed architecture for notifying cooperating nodes of a worm attack, automatic and dynamic quarantine response, generalizable signatures for detection and forensics

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analysis of malicious code that will employ static and dynamic code analysis for program understanding. This effort represents the next step in the continuum of information assurance programs that DARPA has pioneered and pursued.

(U) Program Plans:
- Create architecture for distributing worm alerts and blocking signatures over large-scale networks faster than worm speed.
- Develop automatic detection and quarantine mechanisms.
- Provide real-time and off-line analysis capabilities.
- Develop network appliance and host-based detection/response network interface devices.
- Verify integrated system capabilities.

	FY 2002	FY 2003	FY 2004	FY 2005
Trustworthy Systems	0.000	2.000	9.859	13.605

(U) Sophisticated computing capabilities like those available in current desktop workstation and server systems are moving to mobile wireless embedded systems that communicate over low bandwidth self-organizing tactical networks often with low-powered devices. Concomitant with the advanced computing capability will be security and other trustworthiness challenges in the systems on which the future U.S. military will be heavily dependent during battle. The 21st century transformation of the U.S. military will be more dependent on information technology for C^4ISR and combat functions than perhaps any other aspect of the military. To a large extent, future combat systems will be more dependent on information than armor to accomplish missions successfully. The Department's vision for the future includes near-perfect knowledge of the battlespace and the ability to fight wars with information technology that enables remote C^4ISR operations. The goal of the Trustworthy Systems program is to develop the means to measure and enable trustworthiness in embedded tactical systems and the capability to provide undeniable computer and Internet access into and out of currently denied cyberspace territories. This program will develop mechanisms for software-enabled monitoring, measurement, and control employing design-for-trustworthiness concepts. Key capabilities developed under this program will be the ability to dynamically measure trust based on prior and current system behavior and mission context, optimize a system for a particular trustworthiness attribute such as security, reliability, or performance, and provide real-time monitoring, autonomic and emergency response for when systems begin to behave in a non-trustworthy manner. By leveraging technologies developed in Cyber Panel and High Confidence Systems programs, coupled with network attack responses and embedded systems development, this capability will integrate local attack correlation

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sensors, provide attack visualization tools for local and regional responders, provide continuous update of mission health/impact assessment, and generate course of action auto-planning and execution.

(U) Program Plans:
- Develop fundamental principles and approaches to design for trustworthiness.
- Identify dynamic indicators of system unreliability & insecurity.
- Develop approaches for real-time software monitoring.
- Identify metrics for trustworthiness.
- Develop approaches for empirical measurement of trustworthiness.
- Develop models for software-enabled control.
- Develop methods for undeniable cyber access out of denied territories.
- Explore processors capable of fully encrypting the entire state of computation at each step.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Asymmetric Threat ST-28	56.775	77.034	79.114	80.878	91.284	107.190	119.580	119.513

(U) Mission Description:

(U) The most serious threat to our national security today is *asymmetric* in nature. It is not the threat of a conventional, force-on-force engagement by an opposing military, but instead, the threat of an unconventional yet highly lethal attack by a loosely organized group of transnational terrorists or other factions seeking to influence U.S. policy. This new threat brings new technological challenges to the U.S. The U.S. will need to develop technology to detect, identify, classify, and track small, shadowy, hard to define and identify, and loosely organized terrorist groups as they plan adverse actions against the U.S. This new threat will have a smaller mass, exhibit fewer observables, and yet will be more lethal in consequence. Sparse activity that was once too insignificant to notice will need to be detected, correlated, and understood. This can only be achieved by developing a new level of automation to detect, correlate, and understand all of the observable evidence exhibited by these sparse events. Specific needs include the capability to automatically recognize and identify humans at a distance in order to detect any enemy agent performing surveillance of a U.S. target; to automatically discover, extract, and link together sparse evidence of a group's intentions and activities from vast amounts of classified and unclassified information sources; to more precisely model the beliefs and organizational behavior of these small groups to better simulate and wargame our new opponents in this asymmetric world; and to provide more effective collaborative reasoning and decision aids to improve the speed and effectiveness of distributed teams of analysts and decision-makers in these dynamic situations.

(U) The goal of this project is to develop technological capabilities and a suite of tools to better detect and prevent attacks upon our critical DoD infrastructures. Ongoing programs in this project are Human Identification at a Distance (Human ID), Evidence Extraction and Link Discovery (EELD), Wargaming the Asymmetric Environment (WAE) and Bio-event Advanced Leading Indicator Technology (Bio-ALIRT, formerly referred to as Bio-Surveillance). These programs will provide capabilities to the Total Information Awareness (TIA) network, a program funded in project CCC-03. A suite of new or on-going programs are also funded including Genisys, Genisys Privacy Protection, Mis-Information Detection (MInDet), Activity Recognition and Monitoring (ARM), Future Markets Applied to Prediction (FutureMAP), Scalable Social Network Analysis Algorithms, Next Generation Face Recognition (NGFR), Rapid Analytical Wargaming (RAW), Deception, and Counter Suicide Bombers.

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(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Human Identification at a Distance	16.710	11.120	4.325	0.000

(U) The Human Identification at a Distance (HumanID) program is developing automated multi-modal biometric technologies. These technologies will be used to detect, recognize and identify humans at a distance. Automated biometric recognition technologies will provide critical early warning support against terrorist, criminal, and other human-based threats. Obtaining this information can prevent or decrease the success rate of such attacks and provide more secure force protection of DoD operational facilities and installations. HumanID seeks to develop a variety of individual biometric identification technologies capable of identifying humans at great distances in DoD operational environments and for homeland defense. Once these individual technologies are developed, HumanID will develop methods for fusing these technologies into an advanced human identification system. This system will be capable of multi-modal fusion using different biometric techniques with a focus on body parts identification, face identification, and human kinematics. Biometric signatures will be acquired from various collection sensors including video, infrared and multi-spectral sensors. These sensors will be networked to allow for complete coverage of large facilities. The goal of this program is to identify humans as unique individuals (not necessarily by name) at a distance, at any time day of night, during all weather conditions, with non-cooperative subjects, possibly disguised and alone or in groups. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

(U) Program Plans:

- Designed and administered the Face Recognition Vendor Test 2002 and analyzed and evaluated results.
- Develop a multi-spectral infrared and visible face recognition system and plan to test and evaluate it in operational environments on a large number of subjects.
- Identify the limits of range, accuracy, and reliability on combinations of facial features, gait, and other key identification techniques and determine the critical factors that affect the performance of biometric components.
- Continue the development of the most promising biometric technologies based upon experimental evaluation performance.
- Develop methods and algorithms for fusing multi-modal biometric technologies and deriving biometric signatures.
- Incorporate additional sensors and biometrics into the pilot force protection system.

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- Evaluate and demonstrate the prototype advanced human identification system at force protection and homeland defense sites.
- Use the results of the Face Recognition Vendor Test 2002 to direct face recognition research and provide input to the design of the United States Border Entry/Exit System.
- Perform an operational evaluation of a long-range (25-150 feet) face recognition system developed under the HumanID Program.
- Develop and evaluate a low power millimeter wave radar system for wide field of view detection and narrow field of view gait classification.
- Characterize gait performance from video for human identification at a distance.
- Develop multi-modal HumanID technologies and extend the prototype advanced human identification system by adding two additional biometric modalities.
- Continue to develop biometric fusion algorithms to include up to five biometric components.
- Conduct multi-modal fusion experiments and performance evaluations and develop multi-model fusion algorithms for human identification.
- Demonstrate advanced human recognition capabilities in multiple force protection or homeland defense environments.
- Develop algorithms for locating and acquiring subjects out to 150 meters (500 ft) in range.
- Develop and demonstrate a human identification system that operates out to 150 meters (500 ft.) using visible imagery.
- Fuse face and gait recognition into a 24/7 human identification system.
- Perform an operational evaluation of a multi-modal human identification system.

	FY 2002	FY 2003	FY 2004	FY 2005
Next Generation Face Recognition (NGFR)	0.000	0.000	7.000	10.140

(U) Face recognition technology has matured over the last decade, with commercial systems recognizing faces from frontal still imagery (e.g., mug shots). These systems operate in structured scenarios where physical and environmental characteristics are known and controlled. Performance under these conditions has been documented in the Face Recognition Vendor Test (FRVT) 2000 and in the FRVT 2002 conducted in summer 2002. These evaluations document the advances in this technology. However, these evaluations have also identified performance shortfalls in critical operational scenarios, which include unstructured outdoor environments. The ability to operate in these operational scenarios is critical to military, force protection, intelligence and homeland defense applications. New techniques have recently emerged that have the

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potential to significantly improve face recognition capabilities in unstructured environments. These include three-dimensional imagery and processing techniques, expression analysis, use of temporal information inherent in video, and face recognition from infrared and multi-spectral imagery.

(U) The Next Generation Face Recognition (NGFR) program will leverage and expand upon efforts begun under the Human Identification at a Distance program and will initiate development of a new generation of facial based biometrics that can be successfully employed in a wide variety of unstructured military and intelligence scenarios. The critical components of this program are: 1) a systematic development and evaluation of new approaches to face recognition, 2) maturation of prototype systems at operational sites, 3) experimentation on databases of at least one million individuals, and 4) collection of a large database of facial imagery which includes the variations in facial imagery found in unstructured environments. The NGFR will produce face recognition systems that are robust to time differences between facial imagery (aging), variations in pose, illumination and expression. The required breakthroughs in face recognition will be a result of the coordinated synthesis of the four key components of the program. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

(U) Program Plans:

- Explore new face recognition technologies and approaches and use them to improve the accuracy of existing technologies.
- Incorporate advances resulting from this research into a variety of prototype systems to demonstrate their capability across varied operational scenarios.
- Develop Advanced Imaging Face Recognition Technologies – three-dimensional, infrared, and multi-spectral imaging technologies.
- Collect a comprehensive data set of facial imagery that is representative of faces in unstructured outdoor environments.
- Conduct large-scale experiments and evaluations using large image databases of over a million people.

	FY 2002	FY 2003	FY 2004	FY 2005
Evidence Extraction and Link Discovery	12.309	16.552	10.265	5.515

(U) The objective of the Evidence Extraction and Link Discovery (EELD) program is to develop a suite of technologies that will automatically extract evidence about relationships between people, organizations, places, and things from vast amounts of unstructured textual data (such as

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intelligence messages or news reports) leading to the discovery of additional relevant relationships and patterns of activity that correspond to unusual events, potential threats or planned attacks. These technologies would be employed to provide more accurate advance warnings of potential terrorist activities by known, or more important, unknown individuals or groups. They will allow for the identification of connected items of information from multiple sources and databases whose significance is not apparent until the connections are made.

(U) Recent advances in language understanding software will be exploited to provide a capability to automatically extract facts from textual messages, web pages, and other unstructured data sources at a performance level (90 percent accuracy) comparable to today's ability to extract entities (e.g., people, places, organizations). Search, representation, reasoning, and classification techniques will be developed to enable discovery of relevant information and evaluate it to detect likely threats. Pattern learning algorithms will be extended and scaled to enable learning and evaluation of patterns comprised of relationships among people, organizations, activities, and scenarios, with the ability to distinguish accurately between real activities of interest and explainable unusual events. These technologies will be tested and integrated into the Total Information Awareness (TIA) network. In summary, EELD develops technology not only for "connecting the dots" but also for deciding which dots to connect – starting with people, places, or organizations known or suspected to be suspicious based on intelligence reports, recognizing patterns of connections and activity corresponding to scenarios of concern between these people, places, and organizations, and learning patterns to discriminate as accurately as possible between real concerns and apparently similar but actually legitimate activities.

(U) Program Plans:

- Specify models and corresponding patterns of asymmetric threat scenarios.
- Develop and establish baseline performance for information extraction techniques for extracting geographical, organizational, and transactional relationships from text messages, news reports and web pages.
- Develop ability to discover relevant connections between entities of the same type.
- Develop ability to learn patterns corresponding to threat models comprising connections of single-type entities (e.g., people to people, or sets of related financial transaction) and to discriminate accurately between instances of these patterns representing suspicious activity and representing apparently similar but legitimate activities.
- Implement prototype demonstration of maturing EELD tools and techniques with DoD partners for potential transition opportunity of technologies for near-term support.
- Demonstrate integrated extraction capability for all relationship types from all source types, including rapid adaptability to new types of relationships and new data sources.

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- Develop ability to learn patterns comprising connections of multiple entity types with multiple types of connections and to discriminate accurately between instances of these patterns representing suspicious activity and representing apparently similar but legitimate activities.
- Conduct performance evaluation of all capabilities and model performance of combined capabilities.
- Develop ability to extract links and relationships from processed textual summary of information obtained from streaming (audio/video), imagery and sensor data.
- Develop adaptable relationship extraction capability for extracting facts from all textual sources.
- Develop the capability to recognize and to learn temporal patterns and to discriminate accurately between instances of these patterns representing suspicious activity and representing apparently similar but legitimate activities.
- Implement maturing EELD tools and algorithms in TIA exercises for transitioning into an operational environment via the TIA network.
- Integrate and evaluate EELD component technologies into the TIA network.

	FY 2002	FY 2003	FY 2004	FY 2005
Wargaming the Asymmetric Environment	14.836	18.604	8.221	0.000

(U) The Wargaming the Asymmetric Environment (WAE) program is developing and demonstrating threat specific tools to enable analysts and decision makers to better anticipate, predict, and intervene against terrorists and others who threaten U.S. and Allied interests with asymmetric and asynchronous capabilities. The technical challenges include 1) developing predictive methodologies and technologies that work within the complex and non-linear characteristics of today's asymmetric adversaries, 2) developing predictive technologies that will generalize from individuals to groups, from attack behavior to more subtle enabling behaviors/decisions that precede an attack, and 3) developing emulation (predictive sequences) technologies to allow analysts to test a projected adversary's actions and reactions to potential intervention strategies. WAE's approach to these technical challenges is to exploit a combination of behavioral prediction and computer-based reasoning techniques to automatically identify and model factors reflecting a specific groups "intent" and "points of influence" to support prediction and reasoning – at operationally relevant levels - about the future behavior of individuals and groups. This approach goes beyond today's analytical methods to analyze behaviors in the broader context of their political, psychological, and cultural environment. These predictive technologies will be tested and integrated into the Total Information Awareness (TIA) network.

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(U) Program Plans:

- Establish operational testbeds in conjunction with multiple transition partners (Joint Staff, DIA and CIA).
- Extend predictive model development to finer levels of details of tactic, target, location, timeframe, and severity characteristics.
- Develop predictive models for specific and existing Tier 0 and 1 individual and group adversaries.
- Generalize predictive models from a single adversary to multiple adversaries (asymmetric classes).
- Conduct generalization experiments to empirically define classes of asymmetric threats by common predictive factors.
- Continue to test and validate threat specific models and modeling techniques.
- Transition three predictive models to operational partners.
- Expand predictive modeling to Operations Other Than War (OOTW) context.
- Perform operational, real-time tests through the development and validation of predictive models.
- Perform predictive comparison between the current analytical models and the WAE modified analytical model.
- Extend predictive techniques to develop sequences of behaviors (emulation) for specific and classes of adversaries.
- Transition new and revised predictive models to operational partners.
- Integrate predictive technologies into an automated indication and warning system.
- Beta test automated indication and warning system in conjunction with operational partners (Joint Staff, DIA, and CIA).
- Develop automated tools to optimize the number and content of factors for each predictive model.
- Perform operational tests through the development and validation of emulation models.
- Develop end-to-end automated test environment.
- Develop and test automated, real-time detectors for each predictive models.
- Develop automated model development tools.
- Integrate into TIA network test bed.
- Transition models and predictive tools to operational partners.

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	FY 2002	FY 2003	FY 2004	FY 2005
Bio-ALIRT (Formerly Bio-Surveillance)	12.920	14.173	6.276	0.000

(U) The objective of the Bio-event Advanced Leading Indicator Technology program (Bio-ALIRT) is to develop the necessary information sources, technologies and prototypes capable of detecting a covert release of a biological pathogen by monitoring non-traditional data sources such as animal sentinels, aggregate and anonymized human behavioral indicators, and aggregate and anonymized non-diagnostic and other medical information – such information is statistical and unrelated to personal transaction data. Technical challenges include determining the value of each data source, alone and in combination with others, for earlier outbreak detection, correlating/integrating information derived from heterogeneous data sources, development of autonomous signal detection algorithms with high sensitivity and low false alarms, creation of disease models for autonomous detection, and maintaining privacy protection while correlating depersonalized data sources. The program is identifying, securing and characterizing nontraditional and "gold standard" data sources; developing advanced fusion and detection algorithms and disease models, identifying abnormal health indicators, and processing existing human, agriculture, and animal health data sources to determine the most viable indicators for abnormal health conditions. The program has performed analyses on simulated events to determine which algorithms are most valuable to detect bio-terrorist releases, in addition to its analysis of real world outbreaks for correlation of disease. Dynamic privacy protection that could be placed in a medical data system and ensure the anonymity of individual records are being developed and tested.

(U) A prototype bio-surveillance system has been constructed for cities of high military interest area such as the National Capital Area and one is also being developed for Norfolk, VA. They will show their value through monitoring surrogates for terrorist pathogens, which manifest themselves in early stages as non-specific, flu-like illness. They may also be demonstrated in a series of field experiments by injecting simulated biological event data into the real-time data streams of the testbed system. The Bio-ALIRT program will dramatically increase DoD's ability to detect up to two days earlier using existing data sources a clandestine biological warfare attack, involving both natural and unnatural pathogens, in time to respond and avoid potentially thousands of casualties. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

(U) Program Plans:

- Collect and analyze historical epidemiological data for routine diseases that are surrogates for military-interest pathogens, and also in order to model them as normalcy models against which to measure disease spikes.

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- Develop a biosurveillance system, identify components, and apply these capabilities in a system to detect disease and possible biological attack activity within the National Capital Region and the Norfolk area.
- Identify, access, and analyze additional data sources that may provide earlier indications of biological attack. Characterize promising data sources in different locations over different outbreaks to refine their value as early indicators.
- Refine emulation environment with updated data sources, sensors, data monitoring software models, and detection algorithms.
- Develop data fusion and signal detection algorithms with high sensitivity and specificity.
- Develop privacy protecting algorithms for the integration of heterogeneous data systems that will prevent re-identification of depersonalized data.
- Develop an integrated biosurveillance prototype in a permissive environment (e.g., military base) to determine if more invasive but appropriate means of detection will produce earlier warnings of outbreaks.
- Develop computer simulation environment to emulate bio-terrorist events and impacts on agricultural, animal and human populations.
- Transition data sources and algorithms to existing and developing medical surveillance systems and publish characterized data sources in the literature.

	FY 2002	FY 2003	FY 2004	FY 2005
Genisys	0.000	6.964	7.241	8.588

(U) The Genisys program is producing technology to enable ultra-large all-source information repositories to prevent terrorist attacks on the citizens, institutions, and property of the United States and its allies. The overall goal is to make databases easy to use and easy to populate to increase the level of information coverage, get answers when needed, and share information between agencies faster and easier. To predict, track, and thwart, or at least mitigate attacks, the U.S. needs full-coverage databases including information about all potential terrorists and possible supporters, terrorist materials, training/preparation/rehearsal activities, potential targets, specific plans, and the status of our defenses. Current database technology is far too complex, inflexible, and non-scalable to address the need to integrate all relevant existing databases and information sources, to automatically populate new repositories and to enable the easy creation of new information systems which today exist only in manual form. Only a small fraction of the critical information in the world is stored in a database. If we rely on current commercial database technology, building the new databases we need to combat terrorism will take decades. Today's database technology was defined in the 1970s, but processors, disks, and networks are now thousands of times more capable. Genisys will reinvent database technology to meet today's needs and capabilities.

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Genisys will also stress-test research ideas by developing a series of increasingly powerful leave-behind prototypes so that the intelligence community can get value immediately and provide feedback to focus research. These technologies and components will feed into the Total Information Awareness (TIA) network, which in turn supports the U.S. Army Intelligence and Security Command (INSCOM) in addition to other intelligence organizations to be determined.

(U) Program Plans:

- Develop new counter-terrorism systems by eliminating the need to design databases before using them.
- Simplify the use of databases by eliminating the need to know their internal structure (schema).
- Increase the level of coverage with new methods to auto-populate databases from web content, text, and multimedia information.
- Ensure personal privacy using anonymization, filters, inference control, and immutable audit.
- Automate database integration by developing a database schema crawler and schema translator --- enable fast cross-agency data sharing.
- Improve performance with technologies to automatically restructure databases.
- Create, test, and experiment with a prototype repository that integrates five or more existing databases and semi-structured information sites.

	FY 2002	FY 2003	FY 2004	FY 2005
Genisys Privacy Protection	0.000	3.921	3.982	5.900

(U) The Genisys Privacy Protection Program will create new technologies to ensure personal privacy in the context of increasing data analysis for detecting, identifying and tracking terrorist threats. Information systems and databases have unique potential to aid in identifying potential terrorist signatures. At the same time, Americans are rightfully concerned that the way this data is accessed and analyzed by investigators could threaten their personal privacy. The Genisys Privacy Protection program seeks to enable security with privacy by providing critical data to analysts while controlling access to unauthorized information, keeping personal identity information separate from non-personal data, and ensuring that any misuse of data can be detected and addressed. This program emphasizes the analysis of information, not people, and seeks to prevent access to personal information that may have inadvertently been collected during the lawful collection of information by the intelligence community. Access control and recordkeeping will be automated using business rules that translate policy directly into consistent computer

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processes to provide immutable audit data. This will be accomplished using hardware appliances that can be examined and understood by a third party not affiliated with analysts or investigators (an auditor). To reduce the problem of aggregating information from multiple sources, the Genisys Privacy Protection program will develop statistical and logical inference control systems to analyze queries and provide investigators access to information they need for analysis, while hiding identity and other sensitive data. Finally, Genisys Privacy Protection will create methods and prototype systems that guarantee that audit data cannot be changed, and will also automate the analysis of log data, identifying many types of potential privacy violations so that they can be properly addressed. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

(U) Program Plans:

- Develop privacy algorithms that prevent unauthorized access of sensitive identity data based on statistical and logical inference control.
- Develop roles-based rules for distinguishing between authorized and unauthorized uses of data and automate access control.
- Improve the performance of algorithms for identify protection.
- Develop algorithms for limiting inference from aggregate sources.
- Develop mechanisms and a trusted guard for access control and immutable audit.
- Improve the performance of identity protection algorithms and immutable audit.
- Create methods to automate audit, identify potential privacy violations, and uncover underlying goals and information content from obscure and distributed query sets.
- Develop new information security technologies to ensure personal privacy of U.S. citizen data and confidentiality of intelligence sources and methods. Examples include:
  - Increasing privacy and confidentiality by providing critical data to analysts while controlling access to unauthorized information.
  - Keeping individual identities separate from transaction and intelligence data.
  - Ensuring that any misuse of data can be detected and addressed.

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	FY 2002	FY 2003	FY 2004	FY 2005
Mis-Information Detection (MInDet)	0.000	3.000	5.000	12.000

(U) The objective of the Mis-Information Detection (MInDet) program is to reduce DoD vulnerability to open source information operations by developing the ability to detect intentional mis-information and to detect inconsistencies in open source data with regard to known facts and adversaries goals. A secondary output of the program could be evaluation techniques for use in planning information operations. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

(U) Program Plans:

- Develop domain specific indicators of potential intentional mis-information in open source material using “Red-Team” wargaming techniques and expert knowledge.
- Explore combinations of techniques from linguistic genre analysis, learning with background knowledge, business process modeling, and adversarial plan recognition for detection of intentional mis-information in open sources.
- Develop promising algorithms using a number of approaches (such as combination of linguistic processing, knowledge-based reasoning, and Bayesian Inferencing; decision-tree approach to detect red-flag conditions; deductive anomaly detection; Bayesian technique for evidence fusion; and categorization and concepts extraction) to detect mis-information.
- Demonstrate the ability to detect mis-information in a number of domains such as identifying misleading information in resumes, detecting inconsistencies in news releases between internal and external consumption, classification performance of detection effectiveness and computational resources from known fraudulent/suspicious company websites, and detecting red-flag conditions in SEC filings.
- Demonstrate ability to detect misinformation in open intelligence sources.

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	FY 2002	FY 2003	FY 2004	FY 2005
Activity Recognition and Monitoring (ARM)	0.000	0.000	5.500	9.500

(U) The Activity, Recognition and Monitoring (ARM) program will develop an automated capability to reliably capture, identify and classify human activities in surveillance environments. Currently, these types of activities are identified and analyzed by humans studying real-time and recorded video sequences. ARM technology will dramatically improve the speed and ability to discover and identify anomalous or suspicious activities. Situations where ARM technology will significantly improve current surveillance capabilities include monitoring crowds, searching for unusual patterns of activity, discovering unattended packages and identifying individuals who are casing, loitering, or observing critical facilities. In particular, this includes detecting hostile operatives collecting data on deployed forces, critical infrastructure components, or DoD facilities at home or abroad. The capability to automatically identify and classify anomalous or suspicious activities will 1) greatly enhance homeland defense initiatives by providing increased warning for asymmetric attacks, and 2) increase the reconnaissance and surveillance capabilities for Intelligence and Special Operations Forces. The bases of ARM capabilities will be human activity models. From human activity models, ARM will develop scenario specific models that will enable operatives to differentiate between normal activities in a given area or situation and activities that should be considered suspicious. ARM will develop technologies to analyze, interrupt, model and understand human movements, individual behavior in a scene, and crowd behavior. The approach will be multi-sensor and include video, agile sensors, low power radar, infrared, and radio frequency (RF) tags. The program will produce component technologies, and proto-systems for demonstrating and evaluating performance for multiple scenarios. ARM is a new program for FY 2004 that arose from new research areas identified in the Human ID at a Distance Program. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

(U) Program Plans:

- Develop intelligent activity and monitoring algorithms that are resident in networked sensors.
- Develop a proto-system of networked sensors that is scalable and extensible.
- Demonstrate and evaluate the proto-system on a series of increasingly challenging scenarios.
- Create a database capable of searching observed activities for retrospective analysis.
- Develop human computer interfaces that are tailored to the demands of different users.

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	FY 2002	FY 2003	FY 2004	FY 2005
Futures Markets Applied to Prediction (FutureMAP)	0.000	0.000	3.000	5.000

(U) The Futures Markets Applied to Prediction (FutureMAP) program will develop market-based techniques for avoiding surprise and predicting future events. Strategic decisions depend upon the accurate evaluation of the likelihood of future events. This analysis often requires independent contributions by experts in a wide variety of fields, with the resulting difficulty of combining the various opinions into one assessment. Market-based techniques provide a tool for producing these assessments. Applications include analysis of political stability in regions of the world, prediction of the timing and impact on national security of emerging technologies, assessment of the outcomes of advanced technology programs, or other future events of interest to the DoD. The rapid reaction of markets to knowledge held by only a few participants may provide an early warning system to avoid surprise. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

(U) Program Plans:

- Define and develop prediction markets for events of interest to DoD.
- Define and develop markets for early warning/alarm.
- Develop software and systems for creating, managing and analyzing prediction markets.

	FY 2002	FY 2003	FY 2004	FY 2005
Scalable Social Network Analysis Algorithms	0.000	0.000	3.348	4.040

(U) The Scalable Social Network Analysis Algorithms program will provide a structure to allow the analysis and visualization of linkages of a large number of individuals with associations of memberships in multiple, overlapping, structured organizations and in multiple types of interactions. The program will develop algorithms and data structures for analyzing and visualizing the social networks linkages, implement Algorithms and data structure into software modules that provide social network analysis functionality, and demonstrate this module across the TIA network in a real operational environment. It will focus on developing libraries of social network models that distinguish between terrorist organizations and normal organizations that may on initial superficial examination appear similar in structure.

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(U) Program Plans:

- Develop scalable algorithms and the data structures essential to support the analysis of social networks comprised of large number of individuals who may be linked by a multitude of interactions.
- Explore techniques in graph theory, social network analysis, and mathematics to identify networks of multiple relationships among individuals and/or organizations in open source materials.

	FY 2002	FY 2003	FY 2004	FY 2005
Rapid Analytical Wargaming (RAW)	0.000	0.000	7.500	9.360

(U) The Rapid Analytical Wargaming (RAW) program will develop a faster than real-time analytical simulation to support U.S. readiness for asymmetric and symmetric missions across operational, analytical and training domains. The program will develop technologies to generate a full spectrum of known and emergent behaviors that will expand existing tools developed for more conventional conflict simulation to more realistically portray and project today's asymmetric threats. These technologies will be validated against both historical and real-time world events. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

(U) Program Plans:

- Establish operational testbeds in conjunction with one or more transition partners (DIA and Joint Staff).
- Derive scalable abstract behavioral framework baseline to facilitate the identification and reuse of key military concepts across a broad context and multiple force structures and missions.
- Integrate predictive and descriptive models of existing terrorist individuals and groups into the abstract behavioral framework.
- Develop hybrid gaming technologies that rapidly generate known and emergent behaviors and decisions for asymmetric scenarios based on historical and current context.
- Test initial gaming technologies against both existing analytical tools and recent real-world scenarios.

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	FY 2002	FY 2003	FY 2004	FY 2005
Deception	0.000	1.700	2.456	3.335

(U) The Deception program will develop and demonstrate techniques and sensors to detect deceptive intent during personnel screening for: a) airport screening, b) personnel screening for intelligence and law enforcement agencies, and c) prisoner interrogation. The program will also explore new approaches to develop a scientific basis for understanding human deceptive processes which may lead the way to broad range deception detection applications.

(U) Program Plans

- Determine if high-stakes deceptive behavior can be detected at checkpoints through the discovery of identifiable characteristics of a high stakes target that make him or her stand out from ordinary people even in the presence of clutter and a wide range of subjects.
- Develop insight into the brain/body processes of deception by exploring deep brain processes that may be associated with deception, cultural biases and potential conditioned responses in deceptive situations.

	FY 2002	FY 2003	FY 2004	FY 2005
Counter Suicide Bombers	0.000	1.000	5.000	7.500

(U) The Counter Suicide Bomber (CSB) program will develop and demonstrate collections of technologies which can be used to search for, detect, track, and accurately identify suicide bombers at significant distances and times prior to attack to allow their neutralization with minimal collateral damage. Technologies will focus on remote biometrics to analyze and detect anomalous physiological and psychological behavior, and/or remotely match profiled behavior of known terrorists. The likelihood of a suicide bomber attack in a dense civilian location (e.g., shopping mall or stadium), in CONUS is of increasing concern. Current detection techniques focus on “sniffing” for explosives and other materials, but the bombers’ modus operandi is becoming increasingly clever and nefarious, and may make success of such technical means more problematic. It may be more difficult to conceal psychological and physiological behavior of a bomber imminently close to his or her objective. Remote detection of such behavior could potentially push the neutralization radius out to a location where counteracting the bomber would result in minimal collateral damage, even if the device were to detonate.

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(U) Program Plans:

- Initiate physiology/psychology studies to develop detection/identification requirements.
- Develop CSB system concepts from requirement studies and initiate designs.
- Select demonstration system designs and begin component development.
- Perform demonstration experiments in realistic/operational environments.

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

- Not Applicable.

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RDT&E, Defense-wide BA2 Applied Research	Computing Systems and Communications Technology PE 0602301E, Project ST-29

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Language Translation ST-29	0.000	43.432	57.201	55.883	65.767	65.945	66.196	65.826

(U) Mission Description:

(U) This project will develop and apply new software database management, human language and computer interaction technologies to provide fundamentally new capabilities of critical importance for a wide range of national security needs. This will enable advanced information technology to (a) automatically exploit large volumes of speech and text in multiple languages; (b) revolutionize human-computer interaction using spoken and written English and foreign languages; (c) more effectively accomplish computing and decision-making tasks in stressful, time sensitive situations; and (d) become active, autonomous agents/assistants to the warfighter by collecting, filtering, synthesizing and presenting information in a timely and relevant form.

(U) Most of the programs being funded in this newly created project were previously funded in project ST-11 under this program element. Given the growing importance of automated language translation and speech and text manipulation, a separate project solely for these efforts was considered a necessity.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Situation Presentation and Interaction	0.000	8.770	10.869	7.500

(U) There are two programs involving *human-machine* communication.

- The Babylon program is providing the tactical warfighter with real-time, face-to-face speech translation during combat and humanitarian operations in foreign territories. The program addresses domain-specific translation accuracy and response time. Early prototypes of Babylon technology relying on simple dictionaries and phrases have been deployed on a test basis to Afghanistan. Future versions will offer more sophisticated, flexible and fluid translation and paraphrasing capability that will be more robust and conducive to normal human conversations.

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- The Symphony program is an applied follow-on effort to the Communicator Program, funded under project ST-11, emphasizing technology transition to the military, adaptability and scalability of the Communicator Galaxy Architecture for automatic dialogue in support of C2 (Command and Control) applications. Technologies to be emphasized include human stress adaptation, prosody, and system reliability in military environments. The program will centerpiece six technology insertion projects supporting all services and one commercial application.

(U) Program plans:

– Babylon.
  - -- Establish baseline hardware design for handheld translation technology.
  - -- Upgrade DARPA one-way technology to limited two-way translation.
  - -- Obtain initial software decision approvals for full-featured DARPA two-way translation.
  - -- Conduct multi-lingual data collection in Pashto, Dari, Farsi, Arabic, and Mandarin for contingency operations.
  - -- Produce prototype handheld devices for field evaluations and acceptance.
  - -- Perform initial coordination with U.S. Army PM Soldier for software integration into land warrior Block III (version 3.0).
  - -- Integrate speech recognition engines into natural language parsers and translators.
  - -- Distribute multilingual corpus to R&D community.
  - -- Receive feedback from evaluators on DARPA two-way technology (deliver patches and fixes); units remain in operational use.
  - -- Deliver upgraded handhelds (capable of supporting two-way technology) to software developers.
  - -- Deliver alpha versions of DARPA two-way software for initial user testing.
  - -- Select set of foreign languages for final development.
  - -- Populate language digital resource repository at Defense Language Institute (DLI).

– Symphony.
  - -- Develop FA-18 aircraft maintenance mentor prototype to enhance flight mechanic methods.
  - -- Develop the Battlefield Casualty Reporting System (BCRS), a dialogue driven process to allow casualty reporting and sworn statements to be collected, automated validation and direct reporting to DA (Decision Authority) notification officials.
  - -- Develop a ship based command and control system to allow officers and crew to query ship system status from any location on the ship, set an alarm for a future change in status, or launch agents to monitor particular sub systems.

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-- Create a complete dialogue based interface for all major Total Information Awareness (TIA) Systems to support system navigation and analytical processes; augment search parameters and dialogue based mentoring to assist the novice analyst or enhance the experienced analyst.
-- Conduct a vehicle navigation effort that focuses on the on-the-move environment attacking dialogue base capability in tactical vehicle noise, for the purposes of navigation, command and control and logistical support.
-- Initiate evaluation of dialog technologies for the Institute of Justice for use in multilingual detention facilities.

	FY 2002	FY 2003	FY 2004	FY 2005
Automated Speech and Text Exploitation in Multiple Languages	0.000	34.174	46.332	48.383

(U) There are three programs involving *human-human* communication. These technologies will be tested and integrated into the Total Information Awareness (TIA) network funded in PE 0603760E, Project CCC-03.

- The Translingual Information Detection, Extraction and Summarization (TIDES) program is revolutionizing the way time-critical intelligence is obtained from speech and text by developing technology to enable English-speaking operators and analysts to exploit the huge amounts of foreign speech and text available electronically but currently unexploitable due to vast volumes and insufficient foreign language skills. TIDES is creating powerful new capabilities for Detection (finding or discovering needed information), Extraction (pulling out key information), Summarization (substantially shortening what a user must read), and Translation (converting foreign language material to English). This will dramatically increase the quantity, quality, and timeliness of analysis and reporting by providing vital information to senior decision makers and enabling commanders to carry out critical missions.

- The Effective, Affordable, Reusable Speech-To-Text (EARS) program is creating powerful new automatic speech-to-text transcription technology whose output is substantially richer and much more accurate than currently possible. EARS will provide passive listening technology for critical languages and media for a wide range of national security applications. It will enable effective automated transcription from both broadcasts and telephone conversations.

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- The Global Autonomous Language Exploitation (GALE) program will develop techniques for discovering critical intelligence by autonomously exploiting enormous volumes of streaming speech and text from around the world (in many languages). GALE will enable machines to mine, refine, combine, and package information from broadcasts, conversations, newswire, and internet sources; discover trends and deviations; discern operator/analyst interest from their behaviors (actions and reports); and issue critical alerts, reports, and pointers whenever appropriate (without overwhelming), delivering information in actionable form to military operators and intelligence analysts without requiring them to request it. GALE will build off the successes of both TIDES and EARS.

(U) Program Plans:

– Translingual Information Detection, Extraction and Summarization (TIDES).
  -- Demonstrate capability to detect and track events described in English, Arabic, and Chinese news sources.
  -- Demonstrate capability to extract key information (about people, places, organizations, and relationships) from English, Arabic, and Chinese.
  -- Demonstrate capability to translate Arabic and Chinese documents into readable English.
  -- Define architecture for a unified text and audio processing (TAP) system that integrates various TIDES technologies.
  -- Transition TAP components to operational sites.
  -- Determine ability to port applicable TIDES technology to new languages.

– Effective Affordable Reusable Speech-To-Text (EARS).
  -- Develop automatic techniques to produce rich, readable transcripts of broadcasts and telephone conversations in English, Chinese, and Arabic.
  -- Substantially improve the word-error-rate performance of automatic transcription from approximately 50% down to 5-10%.
  -- Create automatic metadata extraction algorithms to enrich the resulting transcripts and to make them more readable.
  -- Create, demonstrate, and evaluate prototype EARS systems for producing rich transcripts from broadcasts and telephone conversations in English, Chinese, and Arabic.

– Global Autonomous Language Exploitation (GALE).
  -- Initiate multifaceted effort to develop techniques for discovering critical intelligence autonomously, exploiting huge volumes of streaming speech and text in multiple languages.

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	FY 2002	FY 2003	FY 2004	FY 2005
Center for Critical Languages	0.000	0.488	0.000	0.000

(U) Provides funding to assist in the development of a Center for Critical Languages.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Cognitive Systems Learning and Perception ST-30	0.000	10.595	14.822	58.846	102.743	122.139	117.140	107.272

(U) Mission Description:

(U) The Cognitive Systems Learning and Perception project will develop technologies that enable systems to learn and draw on their accumulated experience by applying knowledge gained through such experience to improve performance. These technologies will lead to systems demonstrating increased self-reliance, self-adaptive reconfiguration, intelligent negotiation, cooperative behavior, and survivability with reduced human intervention. Cognitive systems will comprise three primary types of processes: reactive, deliberative and reflective. Each of these will be improved through experimental learning. Reactive processes respond quickly and directly to known stimuli. Deliberative processes embody what is usually known as "thinking." Reflective processes (higher-order) allow a system to "step back" and evaluate the environment and their own capabilities to decide the next appropriate course of action. Different types of learning will improve all of these processes. Capabilities developed in this project include skill learning, pattern detection, and language learning, all of which will extend fundamental computing capabilities.

(U) A remarkable and unique aspect of natural perceptual systems is their ability to take an inordinate amount of raw sensor data, such as visual flow and rich auditory input, filter and integrate that data, and almost instantaneously unify the resultant data into meaningful elements. The human brain is able to create from this information perceptual units that parcel the world into objects and discrete entities that are then recognized, remembered, and used in problem solving. Looking closely at these innate perception abilities will yield insights into how to build totally novel computational systems that notice important, low-frequency events. This kind of approach should lead to dramatic improvements in the abilities of computers to process and analyze huge amounts of data to form a high level understanding within their environment.

(U) In the real-time environment of military operations, networks and systems that can automatically adapt to maintain their critical functionality, and improve these responses over time, will be crucial to operational success. These technologies will make the difference between mission degradation or failure and mission success in the event of cyber-attack or component attrition resulting from kinetic warfare or accidental faults and errors. Systems that learn will reduce the requirement for skilled system administrators and dramatically reduce the overall cost of system maintenance. As the military moves towards a sleek, dynamic expeditionary force, it is critical for systems to be more self-sufficient.

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(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Adaptive Networking	0.000	3.291	5.000	12.700

(U) The Adaptive Networking program will create information and communication networks that possess significant degrees of network self-reliance and responsibility for their own behavior and survival. This includes unprecedented capabilities of self-diagnosis, automatic adaptation to changing and hostile environments, and reconfiguration in response to changes in environment, intelligent negotiation for tasks and resources, and robustness under attack. The project will produce a potentially radical and redesign of distributed computer and device networks and the software that manages them, and will have considerable ability to adapt to unforeseen changes.

(U) Program Plans:
- Identify and characterize the major components of an adaptive/cognitive network and software functionality for large-scale redesign.
- Develop a detailed architectural plan to implement adaptive, self-diagnostic and reconfiguration network capabilities.
- Design and develop a broad collection of specific cognitive network protocols and network management software for automatic statistical diagnosis control.
- Design and implement the experimental cognitive physical network infrastructure.

	FY 2002	FY 2003	FY 2004	FY 2005
Perceptive Assistant that Learns (PAL)	0.000	7.304	8.822	36.146

(U) The Perceptive Assistant that Learns (PAL) program, formerly the Intelligent Micro-Systems Technology program, will build upon prior DARPA programs that developed improved Human Computer Interactions and Highly Responsive computing programs to develop technology for a new class of integrated, highly functional cognitive systems. These systems will act as personalized executive-style assistants to knowledge workers and decision-makers (including military commanders). Initially the program will strive to create assistant programs that will display basic competencies, including interaction with people and other assistant programs in a normal office environment; sending and receiving information in

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a human-like manner; relating office information and activities in various different media; observing the assistant's user and inferring preferences and how to do useful procedures; and accepting advice and guidance expressed naturally in language. Such systems will push the limits of technology for formal reasoning, learning, and computational perception, all integrated in a unified multitasking, mixed-initiative architecture.

(U) The program will demonstrate cognitive systems that make use of past experience and knowledge to help the system understand and seek perceptual input, resulting in systems that do purposeful perception (i.e., sensor information will be filtered and processed to serve specific, high-level goals). Methods for processing raw data will be learned in a way that optimizes performance of the entire system. A unique feature of the PAL program will be the creation of technology for "Lifelogs," ontology-based systems that capture, store, and make accessible the flow of one person's experience in and interactions with the world.

(U) Program Plans:

– Develop baseline architecture for a complete PAL system.
– Develop initial knowledge base representing PAL's knowledge of domain of interest.
– Demonstrate continuous teaming capability over a protracted period of time.
– Develop technology for PAL system to observe user's activities overtime and develop understanding of user's preferences and basic office procedures.
– Develop mixed-initiative technology that enables PAL to ask appropriate questions at appropriate times when confidence in an inference is below threshold.
– Integrate data capture and manual/user-assisted metadata generation capabilities, data storage, and search engine interface to implement a baseline LifeLog capability.
– Establish benchmark tasks for purposeful perception. The benchmarks will include tests of classifying human activities, detecting unusual events, information filtering, and overall system performance.

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	FY 2002	FY 2003	FY 2004	FY 2005
Real-World Learning Technology	0.000	0.000	1.000	10.000

(U) The Real-World Learning Technology program will investigate advanced machine learning techniques and design and develop practical technologies to allow cognitive computing systems to improve their performance and understanding over time. The program will determine which types of learning (e.g., learning by example, learning by analogy, statistical learning from training data, explanation-based learning, etc.) are most effective when applied to challenging problems of importance to the military. It will drive the design and implementation of new, hybrid learning technologies that allow cognitive systems to learn in a wider variety of situations; among other things, these new methods will combine statistical learning techniques with knowledge-based techniques that take into account background knowledge and prior experience. Technologies that allow enduring systems to learn continuously over long periods of time will be developed. Application of this technology will have a dramatic effect on the adaptability and effectiveness of cognitive systems and their ability to perform better over time.

(U) Program Plans:

- Select several critical problems and scenarios to challenge machine learning technology in ways that will determine the essential value of individual techniques.
- Classify a broad variety of problems into classes best addressed with different types of learning technology and determine the most powerful and comprehensive sets of techniques that complement one another.
- Design and develop hybrid learning systems that allow cognitive systems to adapt to a wide variety of naturally-occurring situations and perform better over time against challenges similar to those to which they have been exposed in the past.
- Develop new technologies to address gaps exposed by the above analyses.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Communications, Interaction and Cognitive Networks ST-31	0.000	29.264	42.177	54.433	56.069	49.833	58.570	58.512

(U) <u>Mission Description:</u>

(U) The Communications, Interaction and Cognitive Networks project will dramatically improve warfighter effectiveness by developing revolutionary methods for users to interact with and direct cognitive systems (and the physical sensors and effectors they control) and for large-scale collections of cognitive systems to interact with one another in support of user objectives. Specifically, this project will develop technologies for creating systems capable of instruction, guidance, and persuasion using all forms of natural communication; technologies to enabling systems to detect and assess the user's cognitive state and adapt to optimize understanding and effectiveness of the user; and high-level languages for rapid but precise specification of complex behavior in response to mission demands, such as configuration of sensor networks. Since it is equally important for the warfighter to understand the system as it is for the system to understand the user's intent, this project will develop technologies that give systems the ability to explain and reason about their behavior and actions affecting the external world. Finally, robust interaction among cognitive systems, legacy systems, and humans will require incorporation of advanced models and control of the network infrastructure that connects them to ensure adequate provisioning of quality-of-service under dynamic loads to meet mission requirements. These technologies, taken together, will greatly increase warfighter effectiveness by allowing the warfighter to focus on high-level mission objectives rather than low-level interactions with the system while at the same time ensuring that the warfighter maintains essential understanding of how (and how well) the system is implementing and responding to that high-level direction.

(U) <u>Program Accomplishments/Planned Programs:</u>

	FY 2002	FY 2003	FY 2004	FY 2005
Augmented Cognition	0.000	19.128	21.215	19.202

(U) The Augmented Cognition (AugCog) program focuses on developing technologies to augment the warfighter's cognitive capacity and capabilities. This research area seeks to significantly expand human capability by augmenting human cognition and performance in the way that

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weapons, vehicles, and sensors significantly extend human physical capabilities. The hypothesis of this emerging field is that recent impressive progress in neural science, computation, and miniaturization can now be leveraged to enable new concepts of warfare.

(U) The AugCog program will develop the means, devices, and infrastructure necessary to measure a subject's cognitive state in real time and then manipulate that state in order to greatly improve the performance of various functions in the human-machine interface paradigm. This program will develop the technology to integrate new digital devices that support memory, perception, and thinking, and link that support with the user's context state information to directly improve the overall cognitive performance of the warfighter in complex and operationally stressful conditions. The program will culminate in the development of a closed-loop human-computer interaction capability with the computer able to anticipate, predict, and augment the performance of the user. This technology will also focus on perceptual processing displays that exploit advances in neuroscience and perceptual processing technologies to invent, modify, and redesign devices that deliver information to the human perceptual system. The technology will enable extraction of relevant signal from extraneous background noise. The effort will design and build adaptive multimodal interfaces that improve the ability of the warrior to communicate on the battlefield and exploit all of the digital information currently available only in the static command environment. The long-term impact of this work will be to provide users with vastly expanded expressive power, interface flexibility and transparency, and greater overall utility and robustness of interaction with next-generation digital systems. The technologies developed under the Augmented Cognition program will revolutionize the way 21st Century warriors interact with computer based systems, advance systems design methodologies, and fundamentally re-engineer military decision making processes. This program was previously funded in project ST-19.

(U) Program Plans:

- Evaluate EEG, physiological sensors, and eye tracking technologies that will permit the detection of human cognitive state.
- Integrate physiological and cognitive sensor technologies into a suite of cognitive state "gauges" that will permit the detection and the manipulation of the cognitive state and achievement of order-of-magnitude improvement in human-machine interoperability.
- Demonstrate and evaluate methods to use multi-modal query of digital memory to augment cognition by rapidly re-setting context.
- Develop the technology to autonomously delegate routine or non-urgent tasks to the computer, freeing the user to attend to tasks that demands the user's attention.
- Identify of the underlying neural generators of cognitive state to predict performance under a variety of parameters, such as stress and attention.

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- Develop a set of conversational interruption strategies with cues that help bring a user back into the context of the interrupted task at the point where the user was interrupted.
- Develop a toolkit that allows on-line analysis of a user's self-regulatory mechanisms including sensory response, intentional augmentation of sensation, context updating, performance context tracking, and response and error monitoring.
- Design and demonstrate visual displays and rich audio interfaces to provide the foundation for developing adaptive displays that adjust to the person, task, or display device.
- Design and develop new mobile-adaptive multimodal processing techniques and interfaces concepts tailored to the user, task, and environment, testing their performance and usability advantages within multimodal systems developed in the program

	FY 2002	FY 2003	FY 2004	FY 2005
Collaboraive Cognition	0.000	1.973	7.803	18.616

(U) The Collaborative Cognition program will develop technologies to enable the design and implementation of collaborative agents in dynamic multi-agent environments. Agents should be able to cope with limited and/or noisy sensor information; limited communication capabilities; changing and unforeseen environments and other agents; and limited *a priori* knowledge of each other's capabilities. In contrast to most current systems that address collaboration and teamwork, this program will develop software for controlling agents capable of interacting with both friendly and adversarial agents, and operating in multiple domains and/or varying scenarios within the same domain. In particular, the software will be adept at controlling agents under previously unseen or unknown conditions. This work will explore revolutionary concepts for applying distributed agent technology, first to modeling and simulation systems, with the long-range goal of applying this technology to operational environments, delivering a leap ahead in the capability of intelligent systems. An out-growth of previous DARPA work such as Control of Agent-Based Systems (CoABS), the program can quickly and efficiently explore the application of innovative cognitive and behavior modeling approaches to intelligent agent systems.

(U) Program Plans:

- Develop a strategic control language to specify the behaviors of individual agents and teams of agents regardless of their low-level implementations.

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- Enable agent learning to improve performance against a team of adversaries after observing the team's behavior over an extended period of time, assuming that the adversary's behavior is fixed.
- Develop plug and play modules for cognitive processes and primitive behaviors and increase the intelligence of agents in simulation and autonomous systems.
- Create an ability for agents to monitor, assess and explain the situation in the environment to support autonomous and collaborative behavior with other agents and humans-in-the-loop.

	FY 2002	FY 2003	FY 2004	FY 2005
Self-Aware Peer-to-Peer Networks	0.000	1.502	7.313	16.615

(U) The Self-Aware Peer-to-Peer Networks program, an out-growth of the DARPA Networking program, will develop resilient, scalable sensor-computation networks with decentralized control. This technology will support battlespace awareness by enabling the self-formation of large ad hoc networks of sensors and computational elements within the severely resource constrained environment (power, bandwidth, stealth) of military operations while enabling networks to survive component failure, network intrusion, and the subversion of elements. This self-aware network of sensors and communication will provide a lifeline to the warfighter in the support of effective operations while automating the burdensome and distracting tasks of network deployment, configuration, and management.

(U) High level languages will be developed to map the user's mission plans, including geographical constraints and direct control of individual sensors into network control actions. The sensor networks will function as a distributed form of cognitive system, which dynamically control resources and renders implicit knowledge of itself and its environment. The cognitive network technology will provide on-demand sensing, imaging, and tracking with a prediction/planning capability to estimate the state and trustworthiness of network elements and communication links. Therefore as elements fail or are subverted, the Self-Aware Peer-to-Peer Network will control the graceful degradation for realistic sensing and prediction tasks. This technology will support a variety of networks of manned and unmanned systems.

(U) Program Plans:

- Define and develop cognitive representations, distributed agent coordination technologies, information fusion algorithms, network control language, and network benchmarks.

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- Integrate image recognition, adaptive RF sensors, advanced signal processing for scene analysis and information extraction from sensors.
- Develop a dynamic architecture that defines logic, belief representation, cognitive network protocols, and adaptive target recognition and negotiation techniques.
- Develop mathematical models and algorithms to synthesize intelligent, self-aware, self-forming networks allowing for distributed control.
- Initiate the development/demonstration of robust, secure, self-forming tactical networks.

	FY 2002	FY 2003	FY 2004	FY 2005
Network Modeling and Simulation	0.000	6.661	5.846	0.000

(U) The Network Modeling and Simulation (NMS) program develops software to enable the autonomous prediction, design and control of complex networks over a broad range of time scales, network sizes, composition and performance. New models and simulators will enable reliable and rapid planning, design, analysis and configuration of military and emergency networks with minimal manual intervention. This program was previously funded in Project ST-19.

(U) Program Plans:

- Develop a hybrid simulator integrating fluid and multi-fractal models. Achieve 100x scalability in network size, 50-100x speed in simulation over sequential techniques, for both wired and wireless networks.
- Implement measurement and simulation based, on-line prediction of core Internet, and border gateway protocol, stability and vulnerability, including that arising from virus propagation.
- Develop a simulator suitable for on-line network analysis and control, and scalable to tens of thousands of nodes.
- Demonstrate on line network controls including quality-of-service provisioning, and dynamic reconfiguration.
- Demonstrate 10 to 100 x improvements in time to field new protocols, fault and vulnerability diagnosis, over operator-intensive current techniques.

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- Transition simulation software to DoD clients including DISA, DMSO, FCS, Navy, Air-Force, JFCOM and other service agencies, for use in applications including infrastructure protection, rapid battlefield network design, and network management and control.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-32				
COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Cognitive Systems Foundations ST-32	0.000	13.528	25.833	58.552	61.450	73.283	78.094	82.892

(U) <u>Mission Description:</u>

(U) The Cognitive Systems Foundations project will develop novel system-level solutions through the intelligent integration of cognitive agent capabilities built on robust software and hardware infrastructure. Systems with humanlike capability will need to integrate the cognitive capabilities of reasoning, learning, explaining, ability to be advised, self-awareness and coping robustly with surprise. These aspects of intelligence will be combined in innovative and powerful ways using new cognitive architectures. Overall this element seeks to make fundamental scientific and mathematical improvements in our understanding of and ability to create information and computing systems. Cognitive systems may also form teams to achieve goals in a coordinated manner, exceeding the performance of individual systems or humans working alone. Current fragile commercial systems will have to either be enhanced or radically changed to support this revolutionary objective. The new cognitive foundations will extend beyond today's standard Von Neumann computing model.

(U) The military faces new aggressive and agile threats that have sufficient technical resources to mount sophisticated attacks using easily accessible commercial information systems. The pervasive nature of both the threat and their means drive the need for systems that are able to dynamically adapt, collect and assimilate large quantities of data, and remain robust under a large set of potential failure conditions and threats.

(U) Therefore, the plan is to develop, evaluate, prototype and demonstrate a set of promising concepts in the context of full-scale test-beds in realistic scenarios and environments. These technologies will achieve the goals of developing a computational system with "human-like" capabilities and enhancing humans to act with "machine-like" precision. The next transformational revolution for military force development will be the seamless integration of autonomous physical devices, computation software agents, and humans. Transition goals are military C^4ISR, particularly next generation network-centric systems and platform-specific information collection and processing systems in space, air, sea, and land.

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(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Network-Centric Infrastructure for Command, Control and Intelligence	0.000	9.000	11.028	15.206

(U) The Network-Centric Infrastructure for Command, Control and Intelligence (NICCI) program is developing technologies to automatically create virtual work centers, called "habitats," that can bring together the right combination of people, computer systems, robots, and data to accomplish a specific set of tasks. These habitats can be dynamically reconfigured because they are aware of the interrelated combat conditions and the context of the environment. New technologies will be developed to allow the warfighter, at any level of command, to rapidly assemble a habitat that addresses the needs of a specific task e.g., geographic situation awareness, or command interfacing with teams.

(U) Program Plans:

- Demonstrate use of logical policy specifications to control tasking, resource allocation, and access privileges. Demonstrate ability to extend and revoke policies within and among habitats cooperating on a specified task.
- Demonstrate that a change in data definitions is automatically reflected in data mapping among 5-6 habitats cooperating on a task.
- Demonstrate ability to modify temporal aspects (e.g., frequency of update, mediated by situation) of updates to habitat information from legacy components/systems.
- Demonstrate policy and workflow management capabilities that are operating effectively, and automatically adapt to changes in policies, doctrine, or situational context in a dynamic, multi-layered system-of-systems environment.
- Demonstrate seamless interoperability between heterogeneous systems with the ability to remotely monitor, manage, and reconfigure services and resources. Demonstration will incorporate various communication infrastructures.

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	FY 2002	FY 2003	FY 2004	FY 2005
Self-Regenerative Systems	0.000	3.235	4.000	10.000

(U) The Self-Regenerative Systems (SRS) program will develop the basic precepts of representation, reasoning and learning that will form the scientific foundation for all such future systems. This program will conceive, design, develop, implement, demonstrate and validate architectures, tools, and techniques to field systems capable of adapting to novel threats, unanticipated workloads and evolving system configurations, by employing higher-level cognitive functions such as reasoning, deliberation, and reflection. These technologies will allow future information systems to be dramatically more robust, survivable, and trustworthy than today's systems. Beyond graceful degradation capabilities provided by fault- and intrusion-tolerance mechanisms developed in prior DARPA programs, SRS-enabled systems will be able to reconstitute their full functional and performance capabilities after experiencing an accidental component failure, software error, or even an intentional cyber-attack. Also, they will maintain their robustness and trustworthiness attributes even as they undergo growth and evolution in functionality and performance over time. Such a system will learn from its experience so it performs better tomorrow than it did today.

(U) Program Plans:

- Identify novel attacks and generalize and learn from specific attack events to form a defense against a general set of cyber-attacks and failures.
- Develop technologies to diagnose and assess damage, repair and recover from damage caused by accidental faults, software aging, or malicious activities and, generally, heal the system automatically.
- Develop information systems that can assess dynamic security risks and predicatively adapt their security posture to anticipated threat conditions; and adaptively balance performance and functionality with security.
- Demonstrate scalable data redundancy for network-centric military applications and infrastructure services and develop techniques for natural robustness via biological metaphors to counter vulnerabilities of monoculture in military information systems.
- Develop probabilistic assurance techniques and compos able assurance toolbox to validate self-regenerative properties of information systems.

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	FY 2002	FY 2003	FY 2004	FY 2005
Architectures for Cognitive Information Processing	0.000	0.000	5.280	18.346

(U) The Architectures for Cognitive Information Processing (ACIP) program is developing a new class of processing approaches, algorithms, and architectures to efficiently enable and implement cognitive information processing. ACIP will develop the fundamentals, framework and development environments, algorithms and architectures, and implementations that will provide the basis for and enable innovative and truly efficient cognitive processing. Current intelligent processing implementations depend on the use of existing numerically based architectures and/or standard software architectures, and therefore are implemented via algorithms and processing architectures that are ill-suited to cognitive processes. To realize the impact and promise of cognitive processing, approaches, algorithms, and architectures attuned to cognitive processing fundamentals and that efficiently implement unique cognitive structures need to be established. The ACIP program will establish cognitive processing capabilities that significantly advance the state of the art at all cognitive implementation processing levels – cognitive modules, cognitive systems, and underlying cognitive processing approaches, algorithms, and architectures to support efficient cognitive implementations. In order to focus and establish context for the ACIP program, ACIP will pursue focused in-context DoD mission areas for the development of ACIP concepts. ACIP will develop cognitive implementations that will span the areas of perception, reasoning and representation, learning, and communication and interaction to enable new classes of cognitive information processing applications that will enable an overall goal - systems that know what they are doing.

(U) Program Plans:

- Establish Cognitive Information Framework that will provide common cognitive development environments, tools, and evaluation methods for cognitive algorithm and architecture developments, providing an enduring cognitive basis for a broad set of domains and applications.
- Establish proof of concept and evaluate in-context cognitive application baselines based on current approaches and “best-possible” cognitive implementations on existing processor architectures.
- Characterize the role of reflective reasoning in a cognitive system that reacts effectively to stimuli and also uses deliberation to plan and solve problems.
- Establish and demonstrate a first generation living framework supporting cognitive approach implementation, algorithm development, and architectural evaluation.

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– Select and develop cognitive architecture(s) and in-context applications for cognitive architecture implementations, demonstration and developments.

	FY 2002	FY 2003	FY 2004	FY 2005
Visibly-Controllable Computing (VCC)	0.000	1.293	5.525	15.000

(U) The Visibly-Controllable Computing (VCC) program will leverage the research conducted under Cyber Panel and others to provide a new generation of computing systems that display for their users, their system critical status, provide effective tools for controlling systems critical operations, and enable the system to explain its operation (e.g., current goals, health status) in terms that are appropriate for human consumption. VCC will eliminate confusing and information-free error messages in favor of greater software reliability and, when errors occur, useful explanations. VCC technology will provide a high degree of confidence that computing resources are matched against the user's goals and are not under the control of other entities, as can easily be the case with conventional technology. VCC will revolutionize the security of general-purpose information systems and control the current epidemic of stealth attacks in which attackers take control of systems but legitimate stakeholders never notice.

(U) Program Plans:

– Demonstrate realistic dependency analysis techniques for the interactions between software components.
– Determine the feasibility of building visibly-controllable systems that reduce the occurrence of disruptive system behaviors that confuse users. Develop a collection of system prototypes exploring a range of near-term/long-term design, implementation, and capability tradeoffs.
– Augment current techniques to construct a framework for developing high-assurance behavioral specifications (including security policies) for visibly-controllable systems.
– Demonstrate self-explanation techniques in which systems explain their critical goals and progress towards goals in a manner that is palatable to a variety of human users.
– Demonstrate control mechanisms empowering users to direct their systems towards users' goals while making the system-level consequences of user actions clear in advance.

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(U) Other Program Funding Summary Cost:

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Knowledge Representation and Reasoning ST-33	0.000	18.289	26.451	34.327	58.710	59.604	82.974	102.397

(U) Mission Description:

(U) The Knowledge Representation and Reasoning project is central to the creation of a new class of computational systems – Cognitive Computing Systems. These novel computer-based systems will reason, learn, and respond intelligently to things that have not been previously programmed or encountered. This will be accomplished by creating unique and powerful new abilities for computers to perceive and understand the world, and to reason intelligently with the results of this kind of perception. The real power of human information processing emanates from higher-level capabilities that use abstraction, mental simulation and planning, hypothetical reasoning, powerful language understanding and generation capabilities, and self-awareness. Pursuing the creation of new computational systems without an understanding of the architecture for doing such things would result in a continuation of current relatively unintelligent computational system development. This program will develop novel and effective technologies for representing knowledge of the world in computer-processable form. It will develop accompanying methods of reasoning (including deductive, abductive, planning, strategic, analogical, and flexible methods), which will give the next generation of cognitive computing system important foundations for dealing with real-world information complexity and uncertainty. Instead of pursuing the path of increasing raw computer speed and power, the project will develop approaches that allow computers to reason using explicit structures that represent their knowledge. This substrate of powerful representational capabilities will lead to computer systems being able to plan, solve problems, understand language, understand their own reasoning, and explain their thought processes. This project focuses on two groundbreaking research areas that will develop core cognitive capabilities essential to a cognitive information processing system.

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(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Autonomous Software for Intelligent Control	0.000	14.545	9.085	0.000

(U) The Autonomous Software for Intelligent Control effort will program a variety of autonomous mobile robots to independently perform military tasks in a diverse spectrum of complex, dynamic environments. The goal is to achieve near-human performance in the tasks of perception-based autonomous vehicle navigation and effective interaction of robots with humans. Representations of tasks, goals, plans, common sense knowledge, and perceived environmental features, including the behaviors of humans, are core to this effort. Several alternative approaches are being pursued to augment pre-programmed activities and responses with powerful learning-derived competencies for perception and control analogous to those of biological systems. This software will enable autonomous systems to effectively reason about real-world situations in order to appropriately modify their behaviors. Integrated perception, including fusion of data from multiple sensor and multiple processing modalities of the same data will reduce operator intervention and achieve semi-autonomous operation. The result will be highly capable robots that can learn new tasks and adapt quickly to new environments with minimal programming effort, with numerous applications in the battlespace of the future. This program was funded in Project ST-19 in FY 2002.

(U) Program Plans:

- Demonstrate adaptive generation of complex behaviors; multi-sensor-enabled, outdoor navigation; and methods for directing perceptual attention.
- Develop and demonstrate an integrated robust on-road driving system capable of operating in the proximity of humans and other vehicles.
- Demonstrate a trainable, perception-based, autonomous navigation capability for robots in urban environments.
- Integrate perceptual, behavioral, and natural interactive capabilities onto a humanoid robotic platform, and measure the relative performance of human-supervised and autonomous behavior modes.
- Develop distributed perception-based autonomous navigation behaviors for unmanned surface vessels (USVs) and share information between multiple USVs, to achieve cooperative target tracking, interception, and self-defense.
- Demonstrate cognitively compatible teams of semi-autonomous, semi-independent robots, with adjustable operator interaction modes.

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– Develop infrastructure and tools to seamlessly integrate communications, control, and perception capabilities to implement a networked team of air and ground unmanned vehicles for reconnaissance and area patrol.

	FY 2002	FY 2003	FY 2004	FY 2005
Knowledge Based Systems	0.000	0.000	7.552	17.164

(U) The Knowledge Based Systems program will develop the enabling technologies, methodologies, ontologies, and specific knowledge bases to achieve the next generation of intelligent, knowledge-intensive systems. This work will focus on developing technology that spans the spectrum from large, strategic knowledge banks to personal knowledge pads. The program will develop enabling technologies for codifying, linking, integrating, accessing, and using complex and cross-disciplinary knowledge at widely varying scales. This capability at strategic level will provide DoD decision makers with rapid as-needed access to decision-relevant background knowledge from a broad spectrum of distributed sources. The knowledge will be expressed in formal knowledge representation languages that will allow computers to reason about the knowledge, consider its implications, imagine possible future scenarios, and discuss with the human user all aspects of the information. The significant challenges are centered on the fact that critical knowledge involves temporal information, complex belief structures, and uncertainty, and current representation technology is not adequate to capture such information. This program will also develop the technology needed to enable the creation of a personal knowledge pad which would capture (in a computer understandable form) knowledge of the user's daily tasks and activities. This effort would then provide the user with intelligent automated assistance to help the user plan and accomplish his daily activities and, over time, learn how the user accomplishes these tasks and provide increasingly valuable automated assistance.

(U) Program Plans:
- Develop knowledge module authoring tools.
- Develop methods, protocols, and tools for using interoperable knowledge modules resident on distributed knowledge servers.
- Develop an integrated knowledge representation and learning technology that enables effective representation of essential forms of knowledge. Document a substantial library of formal declarative interoperable multi-use ontologies initially across single, then multiple domains.
- Demonstrate and evaluate prototypes of strategic and personal knowledge-based systems.

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	FY 2002	FY 2003	FY 2004	FY 2005
Advisable Systems	0.000	3.744	9.814	17.163

(U) The goal of the Advisable Systems program is to design and build systems that users can control in natural and flexible ways – not via menus or by programming them, but by exchanging advice and instructions with them. "Advice" will span a spectrum ranging from high-level policy and goals to intermediate preferences and constraints on system behavior to specific direction and contingency actions. Users will be able to express this advice in natural English and engage in a dialogue to clarify/elaborate the general advice. Based on this dialogue, the system will translate the user's intent into an executable plan and start behaving as if it were originally programmed for that function. As Advisable Systems mature, this behavior will increase in complexity from configuration of existing capabilities to the automated acquisition or generation of new capabilities. Advisable Systems will furthermore continuously engage in natural dialogues with users as they encounter unforeseen circumstances or conflicts in priorities and standing orders, eventually becoming fully autonomous in their functioning as commanded. Although progress in this area will require initial focus on selected mission domains to constrain the dialogue, tools will be developed for adapting the technology to other domains. While natural language interfaces are an essential enabler for Advisable Systems, this project will not support speech recognition research per se (except where important conceptual gaps exist that would bear on successful expression of advice and explanations), but rather the development of dialogue management systems that allow systems to glean and clarify user intent. Advisable systems will allow commanders and other decision makers more natural and more productive access to and control over a wide range of software capabilities in a variety of mission-critical areas, including command-and-control, intelligence and logistics.

(U) Program Plans:

- Select two or three key mission domains and compelling scenarios to drive advisable systems research with a series of increasingly difficult challenge problems. Metrics for assessment include "programming" speed and length of dialogue necessary; correctness of resulting system behavior; and performance of the advisable system versus a hand programmed one.
- Develop domain-specific intermediate languages for expressing guidance/advice with precise operational and declarative semantics and tools for translating these languages into either executable plans or parameterized configurations of existing software modules.

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- Develop a dialogue system with domain-specific semantics for eliciting natural language advice from the user. This dialogue system will translate user guidance into the precise intermediate languages described above for both implementation and verification of user intent. Tools for generating dialogue systems from arbitrary domain descriptions will be developed.
- Develop protocols and tools for applying policy preferences and constraints and mediating conflicts among them.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Embedded Software and Pervasive Computing PE 0602302E, R-1 #13

COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	56.190	58.599	13.318	0.000	0.000	0.000	0.000	0.000
Networked Embedded Systems Design AE-01	12.700	20.382	5.650	0.000	0.000	0.000	0.000	0.000
Software for Autonomous Systems AE-02	22.873	22.684	7.668	0.000	0.000	0.000	0.000	0.000
Software for Embedded Systems AE-03	20.617	15.533	0.000	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) Embedded computing provides the connection between the physical world and computation realm. Embedded computing impacts the superiority of a multitude of DoD systems from avionics to smart weapons. Virtually all new weapon systems from the F-22 aircraft to National Missile Defense and from the Future Combat System to Unmanned Combat Air Vehicles depend on embedded software technology. The level of software complexity in these systems is unparalleled. The goal of the Embedded Software and Pervasive Computing program is to greatly extend the reach and effectiveness of computation from mainframes and desktops into the physical world. These embedded programs pursue the software and systems research to facilitate a new emerging application of computers, and conduct research to greatly increase the autonomy of those systems, to promote the human role from that of operator to supervisor, thereby reducing the mission demand for intensive manpower. Embedded system advancements may revolutionize system and software technology to facilitate the efficacy of the integrated battlefield. This program element will draw to a close at the end of FY 2004. Many of these efforts in Embedded Systems have been funded in PE0602702E, project TT-13, to reorient the research towards specific applications.

(U) The Networked Embedded Systems Design project will extend DoD's ability to build complex embedded software systems, which are the primary source of superiority in modern weapons platforms. Embedded software monitors and controls the physical environment, and lends intelligent behavior to platforms. The design and implementation of embedded software systems require an in-depth approach to information systems. Embedded systems will manage the vast quantities of physical information that can be accessed by sensors and actuators in direct contact with the real world. To enable the design of these tightly integrated physical and information systems, network and software infrastructures must be extended to interact with a wide variety of diverse physical world devices and environments. Designs will accommodate vast increases in the

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numbers of nodes with real-time data requirements, and must support operating regimes in which network-based nodes must host services on behalf of embedded clients. Research on embedded software creation must radically extend the technology to enable the modular composition of software systems subject to physical constraints.

(U) The Software for Autonomous Systems project develops revolutionary control technology to enable predictable, safe, and cooperative operation of free ranging, autonomous systems. DoD needs revolutionary new capabilities for increasing autonomy of weapon systems. Increased autonomy will enable combined manned and unmanned warfare, and the extensive use of robotics technologies empowers future war fighters to accomplish their missions more effectively, reducing the risk of casualties, thereby preserving the U.S. military's most important resource–the warfighter. The project builds on major advancements in computing and software achieved during the past decade, which make the practical application of complex nonlinear, hierarchical control techniques feasible.

(U) The Software for Embedded Systems project develops a new class of software to deal with mobile, distributed sensor networks and the processing of physical world information by embedded devices. The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro-sensors that enable a new wave of DoD applications. The effort includes new algorithms and software that allow distributed micro-sensor networks to rapidly and accurately detect, classify, and track threats and events of interest in the battlefield. This effort also includes new technology that will make changes in complex software systems predictably, to ensure the safety and reliability of critical military systems, and to make the systems "self-healing."

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

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	65.561	60.000	50.966	48.520
Current President's Budget	56.190	58.599	13.318	0.000
Total Adjustments	-9.371	-1.401	-37.648	-48.520

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	FY 2002	FY 2003
Congressional program reductions	0.000	-3.401
Congressional increases	0.000	2.000
Reprogrammings	-3.371	0.000
SBIR/STTR transfer	-6.000	0.000

(U) Change Summary Explanation:

FY 2002	Decrease reflects below threshold reprogrammings and SBIR transfer.
FY 2003	Decrease reflects congressional program and undistributed reductions offset by software for autonomous robots add.
FY 2004 - 2005	Decrease reflects reprioritization of Agency requirements and completion of this program. Elements of Embedded Computing have been given application focus and are funded in PE 0602702E, Project TT-13.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA2 Applied Research	Embedded Software and Pervasive Computing PE 0602302E, ProjectAE-01

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Networked Embedded Systems Design AE-01	12.700	20.382	5.650	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) This project extends DoD's ability to build complex embedded software systems, which are a major source of superiority in modern weapons platforms. Embedded software monitors and controls the physical environment, and lends intelligent behavior to platforms. The design and implementation of embedded software systems require an in-depth approach to information systems. Embedded systems will manage the vast quantities of information that can be accessed by physical sensors, and provided to physical actuators, in direct contact with the real world. To enable the design of these tightly integrated physical and information systems, tools to develop software for them must be extended to accommodate a wide diversity of physical world devices and environments with increasingly ambitious performance goals. Designs must support vast increases in the numbers of processors with real-time data requirements. This work radically extends software development technology to enable the modular composition of software systems subject to tight physical constraints.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Model Based Integration of Software	8.990	15.382	5.650	0.000

(U) The Model-Based Integration of Embedded Systems (MoBIES) program is building tools to design and test complex computer-based systems such as avionics, weapons, and communications systems. It simplifies the design of complex embedded systems by focusing on the pre-production environment rather than after-the-fact integration. The approach is to customize the design tools used by applications engineers so that controller design and systems integration can be more fully automated and the errors thereby reduced. The technology will formalize system modeling and programming tools in a common mathematical form. This analysis will allow integrated design of hardware and software from the earliest stages in system development, leading to interoperable tools, automatic systems integration, and simplified test and evaluation. The MoBIES program allows such custom-designed toolsets to be easily tailored to specific applications, resulting in more efficient, verifiable,

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scalable, and re-usable programs for complex weapon and vehicle systems applications. Its objectives are to increase by 100 percent the size of the embedded software programs that existing tools can reliably produce, and decrease by 80 percent the design time necessary to create application-specific tools.

(U) Program Plans:
- Develop methods to integrate different models of computational processes for different applications into a programmable design tool.
- Demonstrate the ability to propagate different physical constraints among design tools.
- Develop hybrid (continuous and discrete) modeling and analysis techniques for embedded systems.
- Develop and demonstrate techniques for the mathematical modeling and formal verification of model-based software generators.
- Demonstrate end-to-end tool integration in avionics, software radio, and vehicle electronics experimental platforms.
- Develop tools for automatically checking safety and reliability properties of automatically generated software.
- Demonstrate the rapid synthesis of embedded systems using customizable frameworks and model-based code generators.
- Develop techniques for integrating different commercial off-the-shelf analysis tools into a single tool environment.
- Develop and demonstrate the use of multiple-view modeling techniques for military avionics, software radio, and combat vehicular electronics applications.

	FY 2002	FY 2003	FY 2004	FY 2005
Adaptive Reflexive Middleware Systems	3.710	5.000	0.000	0.000

(U) The Adaptive and Reflective Middleware Systems (ARMS) program focuses on the Total Ship Computing Environment (TSCE) for the DD(X) Future Surface Combatant Family of Ships. The TSCE will be a fully integrated open system computing and information architecture that executes all tasks and mission applications optimized at the platform level, rather than the sub-system level, thus breaking down the traditional C4ISR, Combat Systems, and Ship Control System boundaries. The TSCE is a mission-critical distributed embedded system where 1) different levels of service are possible and desirable under different conditions and costs and 2) the levels of service in one dimension must be coordinated with and/or traded off against the levels of service in other dimensions to achieve the intended overall result, even in the face of battle damage or heavy workloads. The autonomous behavior of TSCE systems requires the middleware components and frameworks to adapt robustly to

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quantifiable changes in environmental conditions. In ARMS, middleware will be responsible for coordinating the exchange of information efficiently, predictably, scalably, dependably and securely between remote entities by using advanced Quality of Service (QoS) capabilities of the underlying network and endsystems.

(U) Program Plans:

– Develop adaptive protocols, algorithms, patterns, and tools that enforce security policies to enhance and support secure global resource allocation, scheduling, and control; and ensure stability and dependability across multi-level feedback loops in the network-centric TSCE.
– Develop meta-programming policies and mechanisms (instead of application-specific point solutions) to customize QoS -enabled middleware services and applications.
– Develop design expertise (pattern languages) to formalize the successful techniques and constraints associated with developing, generating, and validating QoS-enabled middleware frameworks and protocol/service components.
– Develop reflective techniques for synthesizing optimized real-time and embedded middleware. Develop languages, algorithms, and tools to configure customizable—yet standards-compliant—TSCE middleware and applications.
– Demonstrate sufficiently mature technologies that can transition, with moderate to low risk, to the DD(X) Surface Combatant Family of Ships and other DoD combat systems.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Software for Autonomous Systems, AE-02	22.873	22.684	7.668	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) This project develops revolutionary control technology to enable predictable, safe, and cooperative operation of free-ranging, autonomous systems. Increased autonomy will enable combined manned and unmanned warfare. Extensive use of robotics technologies empowers future warfighters to accomplish their missions more effectively with less risk of casualties, preserving the U.S. military's most important resource. The project builds on major advances in computing and software during the past decade, which has made the practical application of complex nonlinear, hierarchical control techniques feasible.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Common Software for Autonomous Robotics	6.814	5.144	0.000	0.000

(U) The Common Software for Autonomous Robotics program is developing software technologies for large groups of extremely small and highly resource-constrained micro-robots, enabling the coordinated action of many robots to achieve a collective goal while allowing the operator to task and query the ensemble of robots as a group, rather than as individuals. This component addresses four critical areas: 1) coordinated behaviors, including both explicit control strategies that decompose tasks and propagate instructions to individual elements, and implicit control strategies analogous to potential fields; 2) inter-robot communications, including networking protocols that minimize energy consumption and novel alternative communications strategies such as insect-like "pheromone" communications; 3) computational architectures that range from fully distributed processing among the micro-robots themselves to off-loaded processing by a separate "proxy" processing resource; and 4) human-robot interfaces, including both explicit (symbolically grounded) and novel implicit (non-symbolic) user-interface technologies. The payoff will be distributed "swarm" systems of robots that effectively exploit the scalability of large numbers to robustly perform important military tasks such as area surveillance and mine clearing.

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(U) Program Plans:

- Demonstrate energy-saving protocols with at least 70 percent savings over conventional protocol implementations.
- Integrate developmental network protocols into selected distributed robotic platforms and investigate cooperative approaches to achieve critical situational awareness in the indoor application domain.
- Demonstrate realistic mission scenarios using representative distributed robot platforms in a simulated mission context and in field experiments.
- Develop coordination techniques to support accelerated mobility and reconnaissance for cooperating platforms and develop shared representations to support collaborative communication between humans and robotic systems.
- Develop minimal-resource behavioral algorithms and simulation tools to implement highly scalable distributed approaches to simultaneous localization and mapping, communications, and threat detection.

	FY 2002	FY 2003	FY 2004	FY 2005
Software Enabled Control	16.059	17.540	7.668	0.000

(U) The Software Enabled Control program improves the capabilities of control systems for advanced unmanned and manned aircraft. These control systems enhance the autonomy and reliability of both fixed- and rotary-winged unmanned aerial vehicles, and improve the performance of manned vehicles. The challenges are to mathematically model complex changes in flight conditions and vehicle status, to design fast digital control systems to automate maneuvers, and to automatically detect and recover from faults or damage. These techniques will be implemented on a common, open computing platform using a flexible programmer's interface that facilitates reuse of real-time controllers across multiple vehicles. Advanced control system development will exploit recent successes in hybrid systems research, which combine continuous-time systems with randomly occurring discrete events. Hybrid systems can then adapt to sudden changes such as aerodynamic disturbances, threat conditions, damage or failure, or limits in the flight envelope. The software to implement these controls must manage these events and guarantee stable operation throughout the execution of the mission.

(U) Program Plans:

- Develop Open Control Platform (OCP) computing services for advanced control of fixed-wing and rotary-wing air vehicles (e.g., flight mode switching, random event handling, stability and optimization, and reliability).

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- Develop and implement a system for high-confidence authority management for vehicle control and mission-management levels.
- Develop theoretical frameworks for robust hybrid control.
- Develop software customization, failure reconfiguration, and sensor and actuator resource services for unmanned aerial platforms; integrate with OCP.
- Integrate coordinated hybrid system services into OCP middleware, facilitating multi-vehicle coordinated control.
- Develop guaranteed-safe maneuver libraries and control algorithms for coordinated flight.
- Demonstrate integrated controller with active dynamic models for on-line estimation of external influences such as wind fields and carrier deck motion.
- Implement and verify adaptive real-time control algorithms on model vehicles and in hardware-in-the-loop simulation.
- Demonstrate mission-management and dynamic replanning for multiple aircraft using an F-15 and a T-33 UCAV surrogate in coordinated flight.
- Demonstrate low-level autonomous adaptive flight control using rotary-wing UAVs in complex terrains.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Software for Embedded Systems, AE-03	20.617	15.533	0.000	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) This project develops a new class of software to deal with mobile, distributed sensor networks and the processing of physical world information by embedded devices. The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro-sensors that enable a new wave of DoD applications. The effort includes new algorithms and software that enable distributed micro-sensor networks to rapidly and accurately detect, classify, and track threats and events of interest in the battlefield. The effort also includes new technology to make changes in complex software systems predictably to ensure the safety and reliability of critical military systems and to make the systems "self-healing."

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Large Scale Networks of Sensors	12.622	3.993	0.000	0.000

(U) The Large Scale Networks of Sensors component is comprised of the Sensor Information Technology (SensIT) program, which developed new algorithms and software that enable distributed micro-sensor networks to rapidly and accurately detect, classify, and track threats and events of interest in the battlefield. SensIT technologies are valuable for reconnaissance, surveillance, and tactical applications. Technologies developed include robust, reliable, low-latency networking methods than can scale to provide rapid ad hoc networking of fixed and mobile devices, energy efficient algorithms for in-network collaborative processing required to convert multi-modal sensor data to useful information, and algorithms to enable remote querying and accessing data and information collected by the sensor network. A distributed micro-database approach was developed for collecting and storing data, as well as to support dynamic querying and tasking of sensors through a simple language and easy-to-use interface that enables users to access geo-referenced events while hiding unnecessary detail. The program integrated and demonstrated the algorithms and software using iterative design refinement and technology methods and conducted field-experiments jointly with the military and civilian-military advisors.

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(U) Program Plans:

- Optimize embedded node processing and protocols to minimum latency in sensor networks and integrate protocols for interoperation between fixed sensor devices and mobile devices, for lab and field evaluation.
- Implement distributed algorithms for sensor coverage, easy graphical user interface, and collaborative signal processing (including detection, classification, and tracking for a range of military applications).
- Implement technology to support dynamic tasking from multiple simultaneous users, and fusion of information to support collaborative signal processing and the extraction of timely information from the sensor network.
- Conduct field demonstrations to show capabilities of software for tracking of mobile vehicular targets and dismount, and detection and classification of threats in battlefield scenarios. Meet with transition partners and military commanders to continue transition to military units.

	FY 2002	FY 2003	FY 2004	FY 2005
Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA)	7.995	11.540	0.000	0.000

(U) The Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA) Program goal is to create “self healing” systems. Technology is being developed to automatically insert measurement probes and gauges into running (software) systems – allowing them to judge their health and status. Complementary technology will allow the systems to automatically reconfigure themselves to “fix” problems. Major technical challenges include: 1) developing technology to precisely determine and specify the allowable variation in components and their composition; and 2) implementing measures to ensure components fit within functional and non-functional tolerances permitted by dynamically evolving system requirements. Results from DASADA will enable developers and implementers to make changes in complex software systems predictably while ensuring the safety and reliability of critical military systems.

(U) Program Plans:

- Develop and demonstrate a “toolkit” of software components/gauges to simultaneously.
  - Specify and access dynamic architectural models - including dynamic mapping of physical to logical elements.
  - Determine the suitability of components for insertion / reuse in a given system to enable safe run-time composition and deployment.

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-- Enable continuous monitoring of the system to guide adaptation.
-- Ensure that critical (user-defined) properties are maintained during and after composition, adaptation and deployment.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	171.878	161.956	137.254	138.533	139.975	147.104	145.888	145.745
Biological Warfare Defense Program BW-01	171.878	161.956	137.254	138.533	139.975	147.104	145.888	145.745

(U) <u>Mission Description:</u>

(U) DARPA's Biological Warfare Defense project is budgeted in the Applied Research Budget Activity because its focus is on the underlying technologies associated with pathogen detection and remediation. This project funds programs supporting revolutionary new approaches to biological warfare (BW) defense and does not duplicate efforts of other government organizations.

(U) Efforts to counter the BW threat include developing barriers to block entry of pathogens into the human body (including unique methods for rapid air and water purification), countermeasures to stop pathogen and chemical consequence and to modulate host immune response, medical diagnostics for the most virulent pathogens and their molecular mechanisms, biological and chemically-specific sensors, advanced decontamination and neutralization techniques and integrated defensive systems. Program development strategies include collaborations with pharmaceutical, biotechnology, government, and academic centers of excellence.

(U) <u>Program Accomplishments/Planned Programs:</u>

	FY 2002	FY 2003	FY 2004	FY 2005
Unconventional Therapeutics	59.900	45.577	41.045	39.533

(U) This thrust is designed to take unique and unconventional approaches for developing therapeutics for a wide variety of threat pathogens that might be encountered in a biological warfare attack. Countermeasures (e.g., Anti-Virals/Immunizations, Anti-Bacterial/Anti-Toxins, Multi-Purpose, and External Protection) under development include: (1) multi-agent therapeutics against known, specific agents and (2) therapeutics against virulence pathways shared by broad classes of pathogens. Specific approaches include developing a new class of antibiotics targeted

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towards enzymes essential to bacterial pathogen survival, identification of virulence mechanisms shared by pathogens, development of therapeutics targeting these mechanisms, efficacy testing in cell cultures and animals, and advanced non-toxic decontamination strategies, including decontamination from radiological poisoning. The development of an artificial immune system through 3-dimensional tissue engineering will provide rapid, in vitro assessments of novel countermeasures against unique DoD threat agents. This thrust is a combination of three thrusts presented in previous budgets: Anti-Virals/Immunizations, Anti-Bacterial/Anti-Toxins, and Multi-Purpose.

(U) Program Plans:

- Transition three (3) small molecule antibiotic technologies to the United States Army Medical Research Materiel Command (USAMRMC) for continued development.
- Transition two (2) BioWarfare and clinical decontamination technologies to advanced development and commercialization.
- Transition multivalent Dengue DNA vaccine to USAMRMC-Infectious Disease for advanced testing and clinical development.
- Transition novel target discovery platform for late stage anthrax therapeutics to United States Army Research Institution of Infectious Diseases (USAMRIID).
- Transition Botulinum Toxin and Superantigen toxin therapeutics to USAMRMC for advanced testing.
- Transition novel modified red cell scavenging technology to USAMRMC.
- Transition technology for good manufacturing practices (GMP) production of vaccines and antibodies in plants as an alternative to traditional manufacturing procedures.
- Develop and mature technology to treat or prevent infections caused by biological warfare pathogens; discover new targets that would protect against engineered organisms.
- Identify new approaches that will significantly shorten the drug development process and increase the efficiency in identifying lead compounds, using in silico modeling and bioinorganic approaches.
- Accelerate the process of drug development by developing consortia that provide critical assets to drug candidate maturation.
- Improve the efficiency of insertion into the DoD drug development process and shorten the time to FDA approval.
- Demonstrate new drug targets that appear as the disease progresses.
- Discover broad-spectrum therapeutics that attack fundamental and common biochemical processes in bacteria and/or viruses.
- Establish a common test-bed for efficacy, safety and drug metabolism in FDA validated models.
- Assess the feasibility of accurately identifying "drug-able protein targets" from the known primary DNA structure-using novel computing approaches.

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- Rapidly identify novel vaccine targets for bacteria or viruses.
- Develop a rapid response capability for developing candidate DNA vaccines from newly discovered or engineered pathogens.
- Develop new strategies/treatments for late stage biological warfare (BW) infections.
- Develop high sensitivity and high specificity approaches to confirm the presence of a BW pathogen in blood or other biological samples.
- Demonstrate the inherited and environmentally determined risk to BW pathogen infections as a tool in developing unique treatments.
- Develop a totally in vitro system for plague DNA replication to rapidly screen therapeutics.
- Develop a data mining approach to efficiently identify DNA sequences for gene-chip diagnosis of viral and bacterial infections.
- Develop therapeutic approaches that target host biochemistry to deny a broad range of pathogens (within or across classes), the opportunity to infect and cause disease thereby radically changing the prophylactic and therapeutic approach of the DoD to protecting the warfighter in hazardous environments.
- Develop new data analysis capability to interpret biosignature data in individuals incubating a disease.
- Develop an integrated in vitro human immune system, capable of supporting rapid and cost effective vaccine development and testing through the establishment of tools necessary for in vitro fabrication of three dimensional tissue constructs, bioscaffolds and bioreactors.

	FY 2002	FY 2003	FY 2004	FY 2005
Acceleration of Anthrax Therapeutics	30.000	26.000	4.000	0.000

(U) This thrust will accelerate promising anthrax therapeutics (antibodies, immunostimulatory approaches and late stage treatment) into the FDA regulatory process and file an Investigative New Drug application, which would allow the first human safety trials. FY 2003 requirements are partially funded from a transfer from the Defense Emergency Response Fund ($11.250 million).

(U) Program Plans:

- Validate an alternative primate model to replace the current Rhesus monkey model for testing inhalation anthrax therapeutics.
- Establish preclinical primate drug safety and metabolism capability for testing of candidate drugs.
- Demonstrate preclinical efficacy of anthrax antibiotic candidates.

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- Demonstrate preclinical efficacy of immunomodulator drugs against inhalation anthrax.
- Demonstrate preclinical efficacy of late stage anthrax therapeutic candidates.
- Demonstrate preclinical efficacy of a novel adjuvant for currently approved anthrax vaccine (improve safety and speed of vaccination).

	FY 2002	FY 2003	FY 2004	FY 2005
External Protection	6.579	6.000	2.667	3.000

(U) This program is developing and demonstrating a variety of external protection technologies to protect soldiers from the hazards of biological attack. This includes novel water purification approaches as well as developing new approaches for air filtration and purification.

(U) Program Plans:

- Develop, test and transition to the Services a water purification pen capable of disinfecting 300 liters of non-brackish water and a desalination hand pump able to provide 1 liter of sweet water from brackish or seawater in 5 minutes.
- Develop and test a micro fibrous gas adsorbent material with 10-times the gas life and one-half the pressure drop of the current C2A1 gas mask canister.
- Design, develop, test and transition to the Services regenerable air filtration and purification systems suitable for extended personal and collective warfighter and citizen protection.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Diagnostics	5.000	5.000	8.000	10.000

(U) In the early stages, many illnesses caused by BW agents have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The advanced diagnostics efforts will develop the capability to detect the presence of infection by biological threat agents, differentiate them from other pathogens (including those of non-BW origin), and identify the pathogen even in the absence of recognizable clinical signs and symptoms (i.e., while the pathogen numbers are still low).

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(U) Program Plans:

- Evaluate hyperspectral strategies for early clinical diagnosis of infection and other medical issues that affect soldier performance.
- Validate and demonstrate in model systems lead candidate strategies for rapid detection of pathogens based on biomarkers for early indication of infection or exposure.
- Explore and demonstrate new methods for rapid sequencing of DNA.
- Validate and demonstrate strategies for rapidly generating new probe panels for relevant sample types.
- Evaluate and demonstrate multiplexed pathogen detection in microliter samples.
- Demonstrate and rapidly identify a breadth of molecules released in the expired breath following infection (bacterial and viral) that can rapidly and inexpensively triage infected from non-infected individuals before symptoms appear following a bioterrorism event.
- Develop new mathematical and diagnostic approaches to interpret biosignature data from individuals to determine if there will be a change in physiological status from health to disease and vice versa. Use these data to identify the kind of disease and need for treatment.

	FY 2002	FY 2003	FY 2004	FY 2005
Sensors	39.799	37.000	38.000	42.000

(U) Biological Warfare Sensors.

- The ability to rapidly detect biological warfare agents with a low false-alarm rate is a crucial requirement for force protection. To address this need, the Sensors program is creating more efficient and effective miniature sampling technologies that concentrate contaminated air and enhance the ability to capture biological warfare agents. The program is developing a new range of antibodies and “designer small molecules” to bind specific agents that will replace the lower affinity antibodies currently used. A biosensor based on universal probes is being developed for detecting known and possibly bio-engineered pathogens, as an environmental sensor and a diagnostic tool. The use of fluids as a requirement for biological agent detection is also being eliminated and replaced by a miniaturized time-of-flight mass spectrometer. Development of a bacterial biochip to identify genus and species without multiplying the DNA by the polymerase chain reaction (PCR) is also under development, thereby potentially saving over half the time required for identification. A variety of

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applications for these sensors are being explored including protection of buildings from a biowarfare agent attack as well as novel surveillance systems for non-battlefield environments.

(U) Program Plans:

- Demonstrate the production of highly specific antibodies to anthrax by novel technological approach that will reduce cross reactivity between other environmental spores to lower false alarm rate in biosensors.
- Validate that small designer molecules (not antibodies) could be used to accurately capture and identify Bacillus anthracis.
- Demonstrate and evaluate novel binding reporters in biosensors that produced 10-100 times more sensitivity in environmental biosensors.
- Create next-generation biochips to include detection of anthrax, all poxviruses and bacterial toxins using unique and universal nucleic acid sequences from these biological agents.
- Integrate and test small designer molecules into existing biosensors thereby increasing shelf life (ruggedness), accuracy (fewer false alarms) and significantly decreasing the cost of biological detection.
- Assess the use of ion channels (amplification up to 1 million fold) to report the binding of a bioagent and apply the methodology to the creation of a biosensor.
- Demonstrate and validate stand-off technologies, based on laser spectroscopy, acoustics and chemical stains, for detecting and identifying aerosol particles over distances ranging from 100 to 1000 meters in order to provide early warning for the warfighter in the event of a biological attack.
- Evaluate non-intrusive technologies for destruction of biological agents (e.g., ultrasound, variable frequency microwave and new techniques for X-Ray and gamma irradiation) and/or for the detection of chemical agents (e.g., particle neutron elemental analysis, tera-hertz spectroscopy, dielectric spectroscopy, and swept frequency acoustic interferometry).

(U) Organic Based Sensors.

- A unique approach for sensors is the use of cellular, tissue, and organism based sensors for the rapid detection of biological threats. These cellular and tissue-based sensors have the ability to respond to both known and unknown threats, determine live versus inactivated threat status, and report functional consequences of exposure (mechanisms of action). The use of organisms such as insects is also being explored as information collectors for environmental, biological or chemical threats.

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(U) Program Plans:

- Define limits of detection, false alarm rates, and system variability for cell based amplification and detection of biological threat agents.
- Evaluate metrics of performance and demonstrate the utility of social insect biological warfare (BW) agent collector systems in the field.
- Demonstrate the utility of prototype biomimetic fault tolerant robots and their controls in operationally relevant environment (search and rescue, etc.).
- Design and develop sample preparation, processing and delivery methods to maximize bioavailability and activity of the sample and minimize the effect of interferents and fluidics.
- Develop a multitude of critical physiological-based assays that provide information on cellular and tissue responses to a wide variety of threat agents of interest to the Department of Defense.
- Confront the statistical and computational challenges associated with the collection of extremely large datasets from biological sources to include developing software algorithms, models, and data-mining and other bioinformatic tools aimed at determining acceptable parameters of performance and understanding responses profiles.
- Demonstrate the utility of prototype cell and tissue based biosensors in operationally relevant scenarios, including environmental monitoring and medical diagnostics.
- Demonstrate advantages and utility of novel materials developed from mimicking natural biological materials and systems.

(U) Time-of-Flight Mass Spectrometer (MALDI).

- DARPA is developing a small time-of-flight mass spectrometer using Matrix Assisted Laser Desorption/Ionization (MALDI). This approach will enable fluid-free analysis of whole proteins, and therefore make possible fast, reliable biosensors with low false alarm rates and greatly reduced logistics tails.

(U) Program Plans:

- Design and build MALDI time-of-flight (TOF) brassboard system.
- Develop BWA signature libraries and measured clutter characteristics for MALDI TOF brassboard system.
- Design, build, and test optimized MALDI TOF prototype.

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– Develop and validate end-to-end MALDI TOF performance model.
– Characterize MALDI TOF prototype in several indoor and outdoor operational environments.

(U) Nucleic-acid Based Sensors.

- Nucleic-acid based sensors have the advantage that they can detect exact genetic sequences. DNA signatures are fundamental, robust, and durable targets. However, a DNA-based sensor typically requires amplification via polymerase chain reaction (PCR), and this step is often the rate-limiting element of the sensor. In addition, the mere presence of the DNA does not indicate live vs. dead. DARPA is developing technologies to overcome these shortfalls.

(U) Program Plans:
– Evaluate novel amplification processes that do not require polymerase chain reaction (PCR) (e.g., chain reaction replication, non-thermal replication, isothermal signal generation).
– Evaluate enhancements to DNA sensors, such as accelerated culturing coupled with DNA analysis.
– Design, build, and test non-PCR-based DNA sensor, including live vs. dead capability.
– Develop performance model; characterize performance in operational environments.

(U) Triangulation ID for Genetic Evaluation of Biological Risk (TIGER).

- Most nucleic acid based sensors search for an exact sequence match to some unique part of each pathogen. This requires a unique set of primers and probes for every target pathogen; it also means that the sensor can only determine whether that specific (portion of the) target pathogen is present. DARPA is developing a new kind of DNA-based sensor that searches out the universal parts of the genetic code and looks for species-specific variation between these regions. The sensor is called Triangulation ID for Genetic Evaluation of Biological Risks (TIGER). It will enable a universal sensor for all pathogens that also holds the promise of detecting the presence of never-before-seen (bio-engineered) agents.

(U) Program Plans:
– Design and build "gold standard" laboratory instruments for high volume data collection of agent and background signatures.
– Develop and validate end-to-end performance model.

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- Carry out proof-of-concept analysis, and preliminary performance prediction in clutter.
- Design, build and test fieldable prototype(s) optimized for environmental and/or diagnostics applications.
- Characterize prototype behavior in operational environments.

(U) Electromagnetic (EM) Energy.

- Active probing of bioaerosols with electromagnetic (EM) energy holds the promise of extremely fast, and potentially long-range, detection of bio agents. Only a small portion of the EM spectrum is exploited in today's trigger sensors (e.g., optically based particle sizers, sometimes enhanced with fluorescence measurements). However, anecdotal evidence suggests that other portions of the spectrum may offer substantial improvement in trigger sensors, as well as potentially agent-specific discrimination capability. DARPA is investing in this approach, beginning with cross-spectrum data collection and performance models, followed by prototype sensor development.

(U) Program Plans:
- Develop bioaerosol testbed and standardized data-collection protocols.
- Collect data, and develop performance model, for concepts that exploit a wide part of the electromagnetic (EM) spectrum (e.g., Raman scattering, terahertz spectroscopy, laser-induced breakdown spectroscopy, IR/photoacoustics, etc.).
- Downselect to most promising concepts; design, build, and test prototype sensor.
- Characterize prototype behavior in operational environments.

	FY 2002	FY 2003	FY 2004	FY 2005
Immune Buildings	24.000	29.329	32.542	23.000

(U) DARPA is developing technologies for integrated defensive systems to be employed in military buildings to protect and respond to the emerging threat of aerosolized Chemical, Biological and Radiological (CBR) releases. The approach is to modify and augment the infrastructure of buildings to allow them to sense and defeat an attack by bio or chem agents in real-time. The program has three goals: to protect the human inhabitants from the effects of the agents; to restore the building to function quickly after the attack; and to preserve forensic evidence for treatment of victims, if necessary, and for attribution. The DARPA focus is on the challenging problem of protection from internal releases of

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agent, where active and timely control of airflow is required to prevent a building's HVAC system from spreading the agent throughout the building. To enable such building-protection systems, DARPA is developing component technologies such as low-pressure-drop filters, advanced neutralization techniques, fate and transport models to predict agent location and lethality, and remediation techniques appropriate to biological, chemical, and radiological decontamination. In addition, DARPA is investigating the systems-level issues of integrating and optimizing such active systems. These efforts will use full-scale test facilities to determine the effectiveness of protection components and to experiment with various strategies and architectures for protection. These experiments will be followed by a full-scale demonstration of a complete building protection system at a military installation and will leave behind a software tool for the design and optimization of building-protection systems for other military buildings.

(U) Program Plans:

- Develop high-payoff component technologies in the areas of filtration, neutralization, and decontamination; and mature sensors as necessary for this active defense application.
- Demonstrate performance of component technologies in full-scale application.
- Develop active protection system concepts, and estimate achievable performance.
- Build out and instrument full-scale test beds. Conduct experiments to measure actual component performance achievable, as well as the protection afforded by various strategies.
- Select demonstration site. Characterize facility, and design, build, and test an active protection system optimized for that site.
- Integrate existing models, and develop new models as required, into a software toolkit that enables performance predictions for protective architectures in other buildings.
- Validate toolkit predictions in test beds, at demonstration site, and elsewhere as required.

	FY 2002	FY 2003	FY 2004	FY 2005
Wide-Area BW Surveillance	0.000	3.750	7.000	12.000

(U) The Wide-Area Biological Warfare Agent (BWA) Surveillance program will develop and demonstrate effective and efficient BWA surveillance systems for urban environments, such as military bases and transportation centers, to detect a covert aerosol release of a BWA and to determine the approximate release location *before the onset of symptoms in humans*. The program will investigate the key architecture trades, including: the appropriate mix of stationary and mobile assets (collectors/samplers and identification sensors); the value of distributed sampling

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and identification (sensing) versus distributed sampling with centralized identification; the role of layered sensing, such as continuous wide-area surveillance followed by focused/targeted collects for confirmation; the importance of spatial and temporal resolution in enabling backtracking to determine release time and release location; and specialized collection and identification requirements in different environments. These trades will be carried out by modeling covert releases and then analyzing the ability of various architectures (1) to detect the release quickly and (2) to geo-locate the source. System cost and complexity will also be evaluated, and baseline background data will be collected. After the evaluation of candidate architectures, the program will develop a system design; develop the components (samplers, sensors, networking, and algorithms) as required; build and integrate the surveillance system; and demonstrate overall system performance.

(U) Program Plans:
- Conduct trade studies of various potential detection architectures in selected urbanized areas; estimate system performance.
- Develop analytic methods to geo-locate source based on detector output, meteorology, etc.
- Develop optimized components for this application, as required.
- Carry out background characterization experiments.
- Design, build, and test prototype surveillance system. Characterize performance.

	FY 2002	FY 2003	FY 2004	FY 2005
Mother of All Sensor Systems (MASS)	0.000	2.500	4.000	9.000

(U) At present, Nuclear, Biological, and Chemical (NBC) sensors lack a combination of sensitivity (parts-per-trillion) and selectivity (definite identification of molecular species) to overcome their drawbacks of false alarms and even failure of detection at all. This effort will develop a sensor, based upon rotational spectroscopy of gases, which will eliminate both problems and will achieve the highest possible sensitivity for unambiguous detection of biological pathogen byproducts, as well as most other chemical species. The program will focus on technology for reduction of size and simplicity of function, for equipment that presently is large and complicated, to achieve portability and simultaneous detection of multiple (dozens) species. It will solve the presently intractable difficulties of remotely identifying chemical threats, in seconds.

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(U) Program Plans:
- Incorporate advanced solid-state radio frequency (rf) generator and detector into newly designed sample chamber.
- Demonstrate and calibrate improved sensitivity of apparatus for selected species.
- Demonstrate fractionation and related improvements to the system for simultaneous identification of multiple species in seconds.
- Demonstrate capability for dramatic reduction in size and weight of original system, with improved detection sensitivity and selectivity.
- Demonstrate feasibility of prototype portable system for field implementation.

	FY 2002	FY 2003	FY 2004	FY 2005
Center for Water Security	1.000	1.000	0.000	0.000

(U) Program Plans:
- Establish the Center at the University Wisconsin-Milwaukee through engaging essential technical personnel, acquiring state-of-the-art instrumentation dedicated to researching new and highly effective methods of water quality sensing.
- Develop the use of the new methodologies through partnerships with public and private sector agencies to address water security issues related to civilian and military needs.

	FY 2002	FY 2003	FY 2004	FY 2005
Asymmetrical Products for BWD	3.000	2.000	0.000	0.000

(U) Program Plans:
- Develop a technical approach to induce mucosal immunity against BioWarfare pathogens. Model and synthesize a cytokine-based family of compounds that stimulate mucosal immunity.
- Identify likely cytokine molecules and their combinations that result in resistance to pathogens.
- Develop chimeric cytokine drugs using data mining approaches and computer simulation techniques.

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- Synthesize and test chimeric cytokine approaches using in vitro models.
- Test protective approaches in mouse models of clinical and BW infections.

	FY 2002	FY 2003	FY 2004	FY 2005
Desalination Research	2.600	2.300	0.000	0.000

(U) Program Plans:

- Continue developing a non-traditional approach to large-scale desalination of seawater at the ocean shore near available liquid natural gas (LNG) or liquid methane storage facilities, enabling the formation of gas-hydrate-purified, near-potable water ready for final polish by reduced-cost reverse osmosis processes.

	FY 2002	FY 2003	FY 2004	FY 2005
Bioscience Center for Informatics	0.000	1.500	0.000	0.000

(U) Program Plans:

- The Bioscience Center for Informatics will conduct research directed at the rapid detection and modeling of risks associated with defense against bioterrorism, building upon such capabilities as distributed databases, geographic information systems, bioinformatics, high performance computing, and modeling.

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

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	146.680	133.000	142.000	140.000
Current President's Budget	171.878	161.956	137.254	138.533
Total Adjustments	25.198	28.956	-4.746	-1.467

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	FY 2002	FY 2003
Congressional program reductions	0.000	-4.094
Congressional increases	0.000	+33.050
Reprogrammings	+31.622	0.000
SBIR/STTR transfer	-6.424	0.000

(U) Change Summary Explanation:

FY 2002	Increase reflects $30 million of Title IX funds transferred to DARPA and below threshold reprogramming, offset by SBIR transfer.
FY 2003	Increase reflects congressional adds for acceleration of anthrax therapies, asymmetrical protocols, desalination technologies, water security and the bioscience center, offset by congressional undistributed reductions.
FY 2004 - 2005	Decreases reflect completion and transition of several therapeutics efforts.

(U) Other Program Funding Summary Cost:

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA2 Applied Research	Tactical Technology PE 0602702E, R-1 #16

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

(U) Mission Description:

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

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

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

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

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

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

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

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

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

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

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(U) Change Summary Explanation:

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

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03				
COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Naval Warfare Technology TT-03	20.340	25.345	28.857	24.813	14.971	14.656	14.643	14.628

(U) Mission Description:

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

(U) Program Accomplishments/Planned Programs:

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

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

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

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(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

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

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

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

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

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

(U) Program Plans:

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

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

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

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04			
COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Land Systems Technology TT-04	26.812	34.963	41.416	48.806	48.979	46.311	57.463	37.446

(U) Mission Description:

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

(U) Program Accomplishments/Planned Programs:

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

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

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

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

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

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

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

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

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

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

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(U) Program Plans:

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

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

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

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

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

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

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

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

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

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(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

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

- Not Applicable.

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

(U) Mission Description:

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

(U) Program Accomplishments/Planned Programs:

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

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

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(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

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

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

(U) Program Plans:

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

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

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

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(U) Program Plans:

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

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

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

(U) Program Plans:

- Complete concept design.
- Develop experiment design and procure long lead items.
- Conduct experiment.
- Analyze data and integrate with atmospheric compensation programs.

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

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

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

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

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

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(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

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

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

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

(U) Program Plans:

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

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

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

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

(U) Program Plans:

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

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

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

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

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

(U) The Responsive Access, Small Cargo, Affordable Launch (RASCAL) program will design and develop a low cost orbital insertion capability for dedicated micro-size satellite payloads. The concept is to develop a responsive, routine, small payload delivery system capable of providing flexible access to space using a combination of reusable and low cost expendable vehicle elements. Specifically, the RASCAL system will be comprised of a reusable airplane-like first stage vehicle called the reusable launch vehicle and a second stage expendable rocket vehicle. The RASCAL demonstration objectives are to place satellites and commodity payloads, between 50 and 130 kilograms in weight, into low-earth orbit at any time, with launch efficiency of $20,000 per kilogram or less. While the cost goal is commensurate with current large payload launch

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systems, the operational system, through production economies of scale, will be more than a factor of three less than current capabilities for the dedicated micro payload size. This capability will enable cost effective use of on-orbit replacement and re-supply and provide a means for rapid launch of orbital assets for changing national security needs. This program will utilize reusable aircraft technology for the first stage and will take advantage of low-cost rocket technologies for the expendable upper stages. With recent advances in design tools and simulations, this program will prudently reduce design margins and trade-off system reliability to maximize cost effectiveness. This program will also leverage advancements in autonomous range safety, first-stage guidance, and predictive vehicle health diagnosis, management and reporting to lower the recurring costs of space launch. In FY 2003, this program is funded from Project ASP-02, Space Programs and Technology.

(U) Program Plans:

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

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

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

(U) Program Plans:

- Design generator in detail and build and test critical components.
- Build and demonstrate the generator with an available turbine.

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

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

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(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

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

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

(U) Program Plans:

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

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

(U) Other Program Funding Summary Cost:

- Not Applicable.

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

(U) Mission Description:

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

(U) Program Accomplishments/Planned Programs:

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

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

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

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

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

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

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

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

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

(U) The services have a need for affordable, survivable, air vehicles to support dispersed units in littoral and urban areas. The Canard Rotor/Wing (CRW) aircraft offers the potential for a high-speed rapid response capability from a vertical take-off and landing (VTOL) air vehicle with significant range and stealth improvements as compared to other VTOL concepts. Design, fabrication, ground and flight test of a scaled vehicle demonstrator will validate the stability and control system and aerodynamic performance required for vertical take-off, landing and hover via a rotating center wing that stops and locks in place for efficient high speed cruise. Following demonstration of the small-scale vehicle, the program will proceed to design, development and demonstration of more operationally representative vehicles including manned aircraft. In FY 2003, this program is funded in PE 0603285E, Project ASP-01, Advanced Aerospace Systems.

(U) Program Plans:

- Completed ground testing and conducted demonstrator flight tests at Yuma Proving Grounds.
- Completed design and development of follow-on manned and unmanned vehicles.

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

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

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(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

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

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

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

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

- Not Applicable.

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

(U) Mission Description:

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

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

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

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

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

(U) Program Plans:

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

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

- Not Applicable.

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

(U) Mission Description:

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

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

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(U) <u>Program Accomplishments/Planned Programs:</u>

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

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

(U) Program Plans:

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

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

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

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

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

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

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

(U) Program Plans:

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

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

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

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

(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

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

(U) Program Plans:

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

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

(U) Other Program Funding Summary Cost:

- Not Applicable.

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

(U) <u>Mission Description:</u>

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

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

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materials including: structural materials and devices, smart materials and actuators, functional materials and devices, and materials that are enabling for improvements in logistics (i.e., novel power sources, water purification, etc.).

(U) Advances in microelectronic device technologies, including digital, analog, photonic and microelectromechanical (MEMS) devices, continue to have significant impact in support of defense technologies for improved weapons effectiveness, improved intelligence capabilities and for enabling information superiority. The Microelectronics Device Technologies Project supports the continued advancement of these technologies through the development of performance driven advanced capabilities, exceeding that available through commercial sources, in electronic, optoelectronic and MEMS devices, semiconductor device design and fabrication techniques, and new materials and material structures for device applications. A particular focus for this work is the exploitation of chip-scale heterogeneous integration technologies that permit the optimization of device and integrated module performance.

(U) The Cryogenic Electronics project funds specific applications of thin-film electromagnetic materials in electronic devices and circuitry for military applications. Thin-film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military systems. Films may be deposited and patterned to form electromagnetic components in ways that are similar to, and compatible with, the processes of conventional semiconductor manufacturing. Such electromagnetic components, as well as complementary metal oxide semiconductors (CMOS), work best at lower temperatures, so that cryogenic packaging generally will be required for optimum performance. Thin-film high temperature superconducting (HTS) components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance by more than an order of magnitude while reducing size and power requirements. Particular demonstrations include detection and geolocation of targets of high interest based upon low-level characteristic emissions and communications receivers with greater immunity to interference.

(U) The phenomenal progress in current electronics and computer chips will face the fundamental limits of silicon technology in the early 21st century, a barrier that must be overcome in order for progress to continue. The Beyond Silicon project explores alternatives to silicon based electronics in the areas of new electronic devices, new architectures to use them, new software to program the systems and new methods to fabricate the chips. Approaches include nanotechnology, nanoelectronics, molecular electronics, spin-based electronics, quantum computing, new circuit architectures optimizing these new devices, and new computer and electronic systems architectures.

(U) The Biologically Based Materials and Devices Project acknowledges the growing and pervasive influence of the biological sciences on the development of new materials and devices as well as the commensurate influence of materials, physics and chemistry on new approaches to

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biology and biochemistry. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the development of biochemical materials for enhancement of performance, the development of multifunctional transducers based on biological membranes, and the application of magnetic materials in biological applications.

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

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	344.554	440.500	550.126	594.165
Current President's Budget	340.446	434.426	465.544	461.043
Total Adjustments	-4.108	-6.074	-84.582	-133.122
Congressional program reductions	0.000	-19.874		
Congressional increases	0.000	13.800		
Reprogrammings	+0.506	0.000		
SBIR/STTR transfer	-4.614	0.000		

(U) Change Summary Explanation:

FY 2002	Decrease reflects SBIR transfer offset by below threshold reprogramming.
FY 2003	Decreases reflect Congressional program and undistributed reductions, offset by adds in the areas of optoelectronics, photonics, heat actuated coolers, strategic materials, 3D structures and friction stir welding.
FY 2004 - 2005	Decrease reflects reprioritization of Agency requirements.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Materials Processing Technology, MPT-01	162.434	134.744	133.312	135.478	140.495	162.006	158.139	158.959

(U) Mission Description:

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

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Structural Materials and Devices	32.500	33.000	35.073	42.344

(U) The Structural Materials and Devices program is exploiting emerging material science concepts and processing approaches to tailor the properties and performance of structural materials and devices to DoD requirements. Thrusts in this area include new concepts for lightweight personnel protection as well as ultra lightweight materials, amorphous and multi-functional materials for lowering the weight and increasing the performance of aircraft, ground vehicles, and spacecraft structures. Approaches are also being developed for reducing the risk of introducing new materials in defense acquisitions and maintaining them in the field. Techniques are being established for assessing damage evolution and predicting future performance of the structural materials in Defense platforms/systems through physics-based models and advanced interrogation tools. New, low cost processing and fabrication techniques are also being developed to enable expanded use of new materials and structures in Defense applications.

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(U) Program Plans:

- Develop and downselect promising concepts for ultra-lightweight armor with 100 percent improvement over current materials; transition promising concepts to Army vehicle armor programs.
- Develop multifunctional materials concepts designed to provide significant improvement in the capabilities of Defense systems by providing additional functions (e.g., self-healing, thermal control, blast protection, and power) to load bearing structures, quantify their performance and fabricate specific prototype systems.
- Demonstrate multifunctional structure plus battery for micro unmanned air vehicle wing that yields three times more duration than with traditional wing structures and conventional batteries.
- Develop and verify models that predict bulk amorphous metal formation and behavior; use these models to produce bulk amorphous materials with superior properties (including increased fracture toughness and high strain rate behavior) over crystalline material.
- Demonstrate fabrication (forming, joining, etc.) technologies that yield bulk amorphous metals suitable for Defense applications, especially those that require high fracture toughness, even at high strain rates, and quantify the impact of using bulk amorphous materials in construction of land vehicles and naval vessels.
- Demonstrate and validate solutions to critical technical issues for the accelerated insertion of materials that will allow designers to cut the insertion time of new materials by over 50 percent using materials of high value to DoD (turbine metals, aircraft structures).
- Apply the accelerated insertion methodology to new materials that, if inserted, will significantly improve Defense systems.
- Explore techniques for large volume, low cost synthesis and assembly of nanomaterials and nanotubes with controlled attributes; exploit assembly processes to develop hierarchical/topological arrangements and structures to attain unique and multiple properties.
- Develop models and mathematical techniques that, integrated with sensor data, capture the physics of failure and behavior prediction in materials suitable for assessing in-situ damage accumulation and providing current state awareness and structural performance prediction for Defense systems.
- Demonstrate the use of flight information to predict life and failure of critical structural components.
- Demonstrate novel, cost effective processing routes for structural materials of interest to Defense (e.g., Ti).
- Demonstrate novel and reproducible process routes for directed, localized and controlled microstructure modification to achieve substantial improvements in structural material properties of interest to Defense, including bronze castings for Navy applications.
- Explore concepts and demonstrate materials technologies for large, ultra-lightweight and controllable space structures.

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	FY 2002	FY 2003	FY 2004	FY 2005
Smart Materials and Actuators	29.992	31.000	39.739	35.000

(U) In this thrust, smart materials, sensors and actuators for the control of the aerodynamic and hydrodynamic behavior of military systems are being developed and demonstrated to increase performance and lower detectability of aircraft, helicopters, and submarines as well as to increase human performance. New piezoelectric materials are being developed that will dramatically increase the performance of Navy sonar/systems. "Intrinsically smart" materials that provide self-diagnosis and/or self-repair will be developed as well. Machines are being developed that would increase the individual soldier's physical capabilities by augmenting speed, strength, and endurance. Advanced materials, devices, and structural architectures are being investigated that would allow military platforms to morph or change shape, thus adapting optimally to mission requirements.

(U) Program Plans:

- Demonstrate pilot production technology for piezocrystals in quantities and at cost suitable for prototype devices.
- Demonstrate enhanced Naval sonar device/system performance using piezocrystals over a spectrum of representative applications on the laboratory scale, and for a selected few applications on the field scale.
- Develop exoskeleton architectures that are kinematically and dynamically compatible with human physiology.
- Design, demonstrate and validate an integrated, untethered, and self-powered exoskeleton system for augmenting the locomotion and strength of soldiers. The interface of the machine and human will be dramatically enhanced by the development of novel sensor architectures and control algorithms.
- Scale-up piezocrystal materials technology and, in concert with the Services, develop fieldable Defense systems (e.g., sonar) exploiting these revolutionary materials.
- Develop and demonstrate novel fluidic and mechanical devices, and their associated driving electronics, that exploit smart material transducers in order to create new high power actuators for a variety of military applications.
- Develop, design and test the actuators, materials, and control architectures necessary for achieving precise shape change in an airframe to demonstrate the advantages and enable capabilities afforded by the ability to change shape (morphing).
- Extend morphing concepts to Defense platforms beyond aircraft (e.g., spacecraft).

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	FY 2002	FY 2003	FY 2004	FY 2005
Functional Materials and Devices	44.233	28.344	18.500	18.134

(U) For the first time, this thrust area includes programs related to developing advanced functional materials from the former thrust area Mesoscopic Structures and Devices. New materials and concepts are applied to the development of functional materials and devices. This includes advanced magnetic materials for high sensitivity, magnetic field sensors; non-volatile, radiation hardened magnetic memories with very high density, short access time, infinite cycleability and low power; novel materials and device structures for high frequency acoustic imaging; and electroactive polymers for sensing, actuating, and analog processing. New permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings and actuators are also being explored. Unique fabrics that can change their porosity or display information will be investigated. Engineered materials (metamaterials) are being developed that provide improvements in electromagnetic behavior across the complete array of defense applications. Technology for the mask-less, direct-write of mesoscopic integrated conformal electronics will enable the three-dimensional integration of both active and passive components, significantly reducing the size, weight and cost of integrated electronics functions (circuits, batteries, antennae, etc.).

(U) Program Plans:

- Demonstrate the use of conducting polymers for analog processing of image data 10 times faster than and using 10 times less power than digital approaches.
- Demonstrate the use of electroactive polymers in color displays.
- Demonstrate both 1Mbit standalone Magnetic Random Access Memory (MRAM) at high density and high speed and lower density rad hard embedded memory and transitioned to Navy Strategic Programs and DTRA.
- Demonstrate frequency and phase agile antennas, filters, phase shifters, and matching elements and transitioned to Army and Navy communication and remote sensing applications.
- Demonstrate the ability to direct write mesoscale (10 microns to 1 mm) electronic circuitry, conformally, on low temperature substrates (plastic, paper, etc.), using computer aided design/computer aided manufacturing (CAD/CAM) software.
- Demonstrate quantitative advantages of using the electronic capabilities (sensors, transistors, etc.) of electroactive polymers in Defense applications.
- Demonstrate the ability of an electroactive polymer to perform muscle-like sensing and actuation in Defense robotic applications.
- Develop and demonstrate novel magnetic meta-materials including: 1) high temperature, high strength soft magnetic materials for

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rotor and stator applications in turbine environments; and 2) permanent magnets with superior energy products (> 30 MGOe for isotropic systems and > 60 MGOe for anisotropic systems) for DoD motor applications.

- Develop and demonstrate novel microwave meta-materials (including artificial ferrites, nanocomposite ferroelectrics, artificial magnetodielectrics, and negative index materials) that will enable novel antenna and radar designs with reduced size and improved bandwidth and efficiency.
- Demonstrate the ability to conformally direct write large, flexible arrays of functional transistors, filters, and other active electronic components with < 10 micron resolution.
- Demonstrate microfabrication technology for non-silicon MEMS devices and fabricate structures for evaluation.
- Demonstrate feasibility of using functional (conducting, piezoelectric, etc.) fibers and novel textile techniques to create electronic textiles for military applications.

	FY 2002	FY 2003	FY 2004	FY 2005
Materials for Logistics (Air, Water, Power)	35.558	37.000	40.000	40.000

(U) The Materials for Logistics thrust combines the previous categories of Advanced Energy Technologies and those aspects of Mesoscopic Structures and Devices related to logistics technologies. This thrust will apply novel materials and structures to reduce the logistics burden of the warfighter in the field. New materials and concepts for increasing the availability of portable power to the soldier are being investigated, as are approaches for deriving power from the environment for soldiers and sensors. Novel approaches for direct energy conversion from thermal sources such as submarine nuclear reactors are also being examined. New materials and designs will also be applied to the development of novel mesoscale engines (e.g., Stirling, water-lubricated steam engines) that will provide needed power on the battlefield. Hybrid superconducting/cryogenic components will provide a new paradigm for power electronics for the "all electric" platforms of the future. Finally, materials technologies will also be employed in novel approaches for obtaining and purifying water in the field as well as air purification.

(U) Program Plans:

- Fully integrate and demonstrate energy harvesting technologies with military applications.
- Design, develop, and demonstrate portable power sources in the 20 Watt power range suitable for several mission scenarios including: 1) a 3 hour micro air vehicle reconnaissance mission (1000 Whrs/kg); 2) a 3 day land warrior mission (2000 Whrs/kg); and 3) a 10 day special operation forces mission (3000 Whrs/kg).

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- Develop and demonstrate enabling direct thermal to electric conversion technologies with potential for high (> 20%) conversion efficiencies and high (> 1 W/cm^2) power densities for DoD and commercial power generation applications.
- Demonstrate concepts for highly power-dense, man-portable kilowatt generators that will reduce the logistics burden for the soldier in the field.
- Demonstrate efficient, low cost, 200 watt Stirling engine for Defense applications, including powering of small, motorized vehicles.
- Develop and demonstrate unique, energy-saving concepts for obtaining water from non-traditional sources (water-from-air, combusted hydrocarbons, and urine) for the individual warfighter and small groups of soldiers.
- Develop and demonstrate novel technologies for low-power purification of any brackish or salty brine solution.
- Explore novel approaches for power generation based on sonoluminescence, Stimulated Isomer Energy Release (SIER) and other related technologies; transition SIER to project TT-04.
- Demonstrate a prototype hybrid superconducting/semiconducting power module for satellite (100 kW) or terrestrial (5 MW) application with high efficiency and reliability with significantly reduced size and weight.

	FY 2002	FY 2003	FY 2004	FY 2005
Bioinspired and Bioderived Materials and Devices	14.251	0.000	0.000	0.000

(U) This program will explore and exploit the unique characteristics of biologically inspired and biologically derived materials and devices through the understanding, control, and emulation of the structure and chemistry of the interface between man-made and biotic materials, and hybrid bioelectronics that electronically control biological organisms or use biological intelligence for smart materials. The direct utilization of biological systems for the production of unique, bioderived materials will be investigated. Structure and function emulated from biological systems will result in new biomimetic systems that capture unique locomotion and sensing schemes. The fundamental operating principles of biomolecular motors will be developed and exploited to design nano to macro scale devices having unparalleled energy efficiency. Bio-inspired optical components will allow the development of multifunctional optical systems with reduced complexity and weight. Biologically based materials efforts moved to project, MPT-09, in FY 2003, a project created in response to the growing and pervasive influence of biological science on the development of new materials and devices.

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	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Materials, Frequency Tunable Materials	1.500	0.000	0.000	0.000

(U) Program Plans:

- Investigated nano particles for the fabrication of frequency tunable materials and components.

	FY 2002	FY 2003	FY 2004	FY 2005
Strategic Material Manufacturing	3.400	3.400	0.000	0.000

(U) Program Plans:

- Continue to develop new manufacturing approaches for cutting tools and other ceramics used for Defense applications.

	FY 2002	FY 2003	FY 2004	FY 2005
Detection and Destruction of CW-Nanotechnology	1.000	0.000	0.000	0.000

(U) Program Plans:

- Developed all-polymer microelectronic and optoelectronic systems for broad military applications including a polymeric tunneling sensor that combined MEMS technology with nanotechnology and an optical lens system using advanced micro and nano fabrication techniques.

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	FY 2002	FY 2003	FY 2004	FY 2005
Heat Actuated Coolers	0.000	1.000	0.000	0.000

(U) Program Plans:

- Develop compact, lightweight microtechnology-based cooling systems to take advantage of the availability of portable cooling in military and civilian applications where electric power is not available, but waste heat is plentiful.

	FY 2002	FY 2003	FY 2004	FY 2005
Friction Stir Welding	0.000	1.000	0.000	0.000

(U) Program Plans:

- Investigate the applicability using Friction Stir Welding to join amorphous alloys without recrystallization.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Microelectronic Device Technologies, MPT-02	106.678	121.993	163.776	179.073	196.340	209.592	214.399	217.572

(U) Mission Description:

(U) Advances in microelectronic device technologies, including digital, analog, photonic and microelectromechanical (MEMS) devices, continue to have significant impact in support of defense technologies for improved weapons effectiveness, improved intelligence capabilities and for enabling information superiority. The Microelectronics Device Technologies Project supports the continued advancement of these technologies through the development of performance driven advanced capabilities, exceeding that available through commercial sources, in electronic, optoelectronic and MEMS devices, semiconductor device design and fabrication techniques, and new materials and material structures for device applications. A particular focus for this work is the exploitation of chip-scale heterogeneous integration technologies that permit the optimization of device and integrated module performance.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Photonic Wavelength and Spatial Signal Processing (Photonic WASSP)	10.501	9.270	0.000	0.000

(U) The Photonic Wavelength and Spatial Signal Processing (Photonic WASSP) program goal is to develop photonic device technologies that allow the dynamic manipulation of both the spectral and spatial attributes of light for sensing, image pre-processing, bio-chemical sensing and general spectral signature analysis.

(U) Program Plans:
- Develop micro-machined optical elements for spectral bands 300 to 500 nm and 3 to 15 microns.
- Initiate integration of the passive elements into beam conditioners.
- Demonstrate integration with packaging module.

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- Demonstrate module in a testbed for bio-chemical sensing and spectral imaging.
- Transition technology to DoD hypospectral/imaging programs and systems.

	FY 2002	FY 2003	FY 2004	FY 2005
Adaptive Focal Plan Arrays (AFPA)	0.000	5.663	6.875	7.503

(U) The goal of this program is to demonstrate high-performance focal plane arrays that are widely tunable across the entire infrared (IR) spectrum (including the short, middle and long-wave infrared bands), thus enabling “hyperspectral imaging on a chip.” The Adaptive Focal Plane Array (AFPA) program will also allow for broadband Forward Looking Infrared (FLIR) imaging with high spatial resolution. These AFPAs will be electrically tunable on a pixel-by-pixel basis, thus enabling the real-time reconfiguration of the array to maximize either spectral coverage or spatial resolution. The AFPAs will not simply be multi-functional, but rather will be adaptable by means of electronic control at each pixel. Thus, the AFPAs will serve as an intelligent front-end to an optoelectronic microsystem. The AFPA program outcome will be a large format focal plane array that provides the best of both FLIR and Hyper-Spectral Imaging (HSI).

(U) Program Plans:
- Develop component technology (tunable IR photodetectors).
- Integrate detector array.
- Demonstrate pixel-by-pixel electrical tunability in IR.
- Demonstrate AFPA prototype field using a large format array.

	FY 2002	FY 2003	FY 2004	FY 2005
Vertically Interconnected Sensor Arrays (VISA)	8.954	11.550	11.983	10.773

(U) The Vertically Interconnected Sensor Arrays (VISA) program will develop and demonstrate focal plane array (FPA) read-out technology capable of extremely high dynamic range sensitivity enabling significant advances to the functionality of infrared systems. This will be achieved by the development of novel vertical 3D integrated read-out circuits for sensor arrays designed with advanced high performance circuit architectures. A wide range of military imaging systems will be enabled, i.e., detection of targets appearing in low contrast, high clutter, or low light scenes and laser jamming avoidance.

(U) Program Plans:

- Develop a wafer stacking process incorporating high-density vias and design novel circuits that enable high frame rates, counter measure hardening and adaptive signal processing functions on a concept test chip.
- Demonstrate a high dynamic range A/D VISA technology based sensor designed with advanced high performance circuit architecture implemented in stacked semiconductor process with high-density interconnections.

	FY 2002	FY 2003	FY 2004	FY 2005
Imaging Coherent Optical Radar	0.000	0.000	5.000	7.000

(U) This program, utilizing extremely high speed imaging nanotechnology, will develop new coherent optical radar cameras, up to GHz sampling rate, for imaging/non-imaging high sensitivity vibrometry, Doppler and intensity measurements, and achieve extremely fast high performance imaging in small, low power, reduced thermal load, producible devices for insertion throughout the military community. The technology will do what radar does, but with an optical carrier and optical resolution.

(U) Program Plans:

- Demonstrate nanofabrication techniques for realizing broadband coherent optical sources with tailored spectral output for imaging, communication, targeting and countermeasure applications.

	FY 2002	FY 2003	FY 2004	FY 2005
Highly Integrated Millimeter Wave Electronically Scanned Array	0.000	0.000	3.000	5.000

(U) The Highly Integrated Millimeter Wave Electronically Scanned Array (ESA) program will investigate the possibility of making complete millimeter wave active arrays on a single or a very small number of wafers. The program will exploit new technologies being developed commercially that allow GaAs active components to be placed on Si wafers, and advances in InP and SiGe that may allow an entire MMW ESA to

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become very highly integrated on a sandwich of wafers. At lower frequencies, the large spacing between radiating elements precludes the efficient use of the wafer real estate for fabricating the entire ESA, but at Ka and W- bands, the element spacing is small enough to allow an ESA to be made with active transmit/receive chips and control circuits on one layer, radiators on another, and a feed system on a third. This could potentially make them very cheap, compact, lightweight and reliable. This would enable the development of new MMW ESAs of a six inch diameter or less for seekers, communication arrays for point-to-point communications, sensors for smart munitions, robotics and small remotely piloted vehicles.

(U) Program Plans:

- Survey the emerging commercial MMW technology base and identify the best candidate processes for the MMW ESA application.
- Develop the optimal ESA architectures for wafer fabrication.
- Determine requirements for MMW ESAs that match the expected performance.
- Design, build, and test candidate ESA designs.
- Design, build, and test full ESA seeker or other system using the wafer fabrication technology.

	FY 2002	FY 2003	FY 2004	FY 2005
Analog Optical Signal Processing (AOSP)	7.334	12.008	14.733	14.808

(U) Analog Optical Signal Processing (AOSP) will significantly enhance the performance of, and enable entirely new capabilities and architectures for tactical and strategic RF systems. The program will expand the dynamic range-bandwidth and time-bandwidth limits by a factor of 1,000 through the introduction of analog optical signal processing components into the system front ends.

(U) Program Plans:

- Perform analysis of analog signal characteristics of military RF systems.
- Create, model and simulate new photonic-based optical signal processing techniques of ultra-high bandwidth analog signals.
- Evaluate anticipated system performance improvements due to novel signal processing algorithms and determine the resulting photonic component performance requirements.
- Test and evaluate signal processing techniques of analog signals.
- Evaluate photonic component performance requirements.
- Design, fabricate and test individual photonic components capable of meeting RF signal processing requirements.

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– Determine the most promising approaches for development of integrated, chip-scale components using new materials and processing technologies.
– Determine interface requirements.
– Evaluate the suitability of the new components for use in prototype modules.
– Down-select to the most promising approaches and begin prototype module assembly.
– Construct testbeds capable of fully characterizing the photonic-based RF signal processing components.

	FY 2002	FY 2003	FY 2004	FY 2005
Precision Optical Oscillators	0.000	0.000	3.929	4.904

(U) The Precision Optical Oscillator program will leverage advances in materials and lasers to develop new precision microwave stable local oscillators with extremely low phase noise (up to 50 dB better than the current state of the art) at small offsets from microwave carrier frequencies. This is extremely important for radar, electronic warfare and communications applications in weak signal detection at increased stand off ranges, slow moving target detection, clutter suppression, and electronic warfare "fingerprinting (specific emitter identification).

(U) Program Plans:
– Improve phase noise power spectral density by 25 dB and prove the utility of multi-line laser cavities and opto-electronic oscillators. Identify and characterize environmental susceptibilities and define path to 50 dB improvement over state of the art.
– Demonstrate 50 dB improvement in lab setting.
– Develop miniaturization approach and packing concept to mitigate environmental susceptibilities.
– Miniaturize devices in ruggedized packages.
– Demonstrate performance in tactical environments insert in system testbeds.

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	FY 2002	FY 2003	FY 2004	FY 2005
Intelligent Digitization of Analog Sensor Information	0.000	0.000	6.000	9.000

(U) The overall goal of the Intelligent Digitization of Analog Sensor Information program is to significantly advance analog/digital conversion technology for insertion into a wide variety of military platforms. A specific goal is a ten fold improvement in the data conversion metric (bandwidth X resolution/power). A promising approach is to develop and implement new high performance architectures that overcome the limitations of current analog mixed signal circuits by harnessing the enormous calculational power of the most aggressive digital CMOS technology. This program will seek new, innovative approaches to A/D circuit design and transition the most promising architectures to the Defense industry for refinement and incorporation into Defense sensor systems. The resulting technology will impact many Defense communications, radar, and SIGINT systems.

(U) Program Plans:

- Identify application for adaptable mixed-signal processors, component requirements, and technical challenges.
- Identify concepts for adaptable mixed-signal processor functions including flexible interconnect networks, data flow sensors, optimization algorithms and data routers.
- Demonstrate concepts for chip-level flexible interconnects.
- Demonstrate algorithms and circuits for architecture optimizers.
- Complete design concepts for data flow sensors, resource allocation, and data-traffic routers.
- Demonstrate adaptability concepts in digital and mixed signal circuits.
- Demonstrate communication between adaptable mixed-signal and digital circuits.

	FY 2002	FY 2003	FY 2004	FY 2005
Chip Scale Atomic Clock	5.963	13.196	12.636	12.750

(U) The Chip Scale Atomic Clock will demonstrate a low-power chip scale atomic-resonance-based time-reference unit with stability better than one part per billion in one second. Application examples of this program will include the time reference unit used for GPS signal locking.

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(U) Program Plans:

- Demonstrate feasibility and theoretical limits of miniaturization of cesium clock.
- Demonstrate subcomponent fabrication, including atomic chamber, excitation and detection function.
- Demonstrate design and fabrication innovation for atomic-confinement cell and for GHz resonators suitable for phase locking or direct coupling with atomic confinement cell.

	FY 2002	FY 2003	FY 2004	FY 2005
Technology Efficient, Agile Mixed Signal Microsystem (TEAM)	7.390	12.348	16.863	16.712

(U) Technology for Efficient, Agile Mixed Signal Microsystems (TEAM) will enable fabrication of high performance mixed signal systems-on-chip that will be the core of the embedded electronics in new platforms that are constrained by size and on-board power.

(U) Program Plans:

- Develop and demonstrate nanoscale silicon-based structures and associated fabrication processes to achieve high-speed analog/RF functions.
- Optimize device and process parameters for high speed mixed signal circuits.
- Produce test devices for analog/RF parameter extraction.
- Demonstrate Complementary Metal Oxide Semiconductor (CMOS) compatible fabrication processes that can yield integration levels greater than 10,000 nanoscale devices.
- Initiate highly parallel densely interconnected architectures with micron-sized vias penetrating stacks of detectors, analog, mixed signal and digital circuits.
- Demonstrate operation of high performance mixed signal circuits based on nanoscale devices.
- Demonstrate low noise interface and high isolation (up to 100 db) between high performance analog circuits and associated digital signal processing.
- Fabricate mixed signal systems on chip with nano-scale transistors.

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	FY 2002	FY 2003	FY 2004	FY 2005
Technology for Frequency Agile Digitally Synthesized Transmitters (TFAST)	0.000	21.337	21.050	19.000

(U) The TFAST program (Ultra High Speed Circuit Technology) will develop super-scaled Indium Phosphide (InP) Heterojunction Bipolar Transistor (HBT) technology compatible with a ten-fold increase in transistor integration for complex mixed signal circuits. Phase I will establish the core transistor and circuit technology to enable the demonstration of critical small scale circuit building blocks suitable for complex mixed signal circuits operating at speeds three times that currently achievable and ten times lower power. Phase II will extend the technology to the demonstration of complex (more than 20,000 transistor) mixed signal circuits with an emphasis on direct digital synthesizers for frequency agile transmitters.

(U) Program Plans:

- Develop material and process technology for super-scaled InP double heterostructure bipolar transistors (DHBTs). Technical approaches will leverage the process technology used in the silicon, and silicon germanium, industry to produce a planar, highly scalable InP HBT.
- Extend the core DHBT and interconnect technology with the implementation of complex mixed signal circuits.
- Develop super-scaled InP HBT processing technology for 0.25 micron and below.
- Develop high current, planar, InP HBTs compatible with high levels of integration.
- Develop greater than 100 GHz mixed signal circuit building blocks.
- Demonstrate record performance InP HBTs in a planar process for complex mixed signal circuits.
- Demonstrate critical mixed signal building block circuit operating at more than 100 GHz.
- Develop circuit designs for direct digital frequency synthesizers (DDS) operating with clock speed up to 30 GHz.
- Define circuit designs and layouts for mm-wave DDS and related complex mixed signal circuits.
- Develop full circuit capability using super-scaled InP HBTs in complex (more than 20,000 transistor) circuits.
- Established device models and critical design rules.

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	FY 2002	FY 2003	FY 2004	FY 2005
Clockless Logic	0.000	0.000	4.911	7.808

(U) The Clockless Logic program goal is to develop techniques to reduce the amount of design resources required in chip design and significantly reduce the power and noise to provide improved system operation. Clockless methods will provide more efficient designs especially for military systems with demanding space, weight, power, and noise constraints.

(U) Program Plans:
- Develop method for design of complex chips using clockless logic.
- Enhance tools and methods for design of clockless logic circuits and systems.
- Identify and design complex chips with significant potential for improved system performance and reduced design times.
- Apply clockless design methods to programmable logic devices to provide significant potential for improved system performance and reduced design times.
- Demonstrate performance enhancements of complex chip enabled by clockless logic in radar or similar testbed.

	FY 2002	FY 2003	FY 2004	FY 2005
Interfacing Nanoelectronics	0.000	0.000	6.000	8.000

(U) As IC technology progresses towards nano (less then 100nm) dimensions, the transistors and logic blocks are becoming smaller and faster than the interconnects. On-chip wiring is now a major limiter in logic delay, power dissipation and yield, a situation that will be seriously aggravated in nanoelectronic systems. Interconnects directly affect performance and power dissipation of digital processors, which are pervasive in DoD systems. Additional stringent demands on interconnects will be generated by "new frontier" nanowire or single-molecule-based devices scaled down to nanometer dimensions that are expected to be the backbone of future generation computing and communication systems. While performance is a critical limitation, existing interconnect solutions also introduce considerable noise into the system because of electromagnetic coupling between closely spaced lines. Such issues must be overcome to achieve future advanced sensor systems. This program will develop novel methods for advanced interconnect technology at all levels (board to chip) with primary emphasis on overcoming on-chip bottlenecks.

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(U) Program Plans:

- Develop alternatives to wired interconnects to include both optical and RF.
- Implement reduced interconnect length methods based on 3D interconnected systems, either by multiple layers of transistors or by 3D stacked chips in a single package.
- Apply communication network and signaling approaches to minimize electrical interconnect length in the design of complex signal processing chips.
- Develop new system-in-a-package concepts for heterogeneous systems (multiple functions and multiple materials integrated via interconnect) that includes advanced thermal management and self-contained power elements.
- Develop integrated modeling and simulation tools capable of thermoelectromechanical system design.

	FY 2002	FY 2003	FY 2004	FY 2005
Design Tools for 3-Dimensional Electronic Circuit Integration	0.000	0.000	6.000	7.000

(U) This program will develop a new generation of CAD tools to enable the design of integrated three-dimensional electronic circuits. The program will focus on methodologies to analyze and assess coupled electrical and thermal performance of electronic circuits and tools for the coupled optimization of parameters such as integration density, cross talk, interconnect latency and thermal management. The deliverables from this program will have a significant impact on the design of mixed signal (digital/analog/RF) systems and Systems-on-a-Chip for high performance sensing, communication and processing systems for future military requirements.

(U) Program Plans:

- Apply 3D design tools to test structure.
- Fabricate and test structures.
- Verify models against data.

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	FY 2002	FY 2003	FY 2004	FY 2005
Chip-to-Chip Optical Interconnects	0.000	0.000	3.000	5.000

(U) Continuing advances in integrated circuits technology are expected to push the clock rates of CMOS chips into 10GHz range over next five-to-seven years. At the same time, copper-based technologies for implementing large number of high speed channels for routing these signals on a printed circuit board and back planes are expected to run into fundamental difficulties. This performance gap in the on-chip and between-chip interconnection technology will create data throughput bottlenecks affecting military-critical sensor signal processing systems. To address this pressing issue, the proposed program will develop optical technology for implementing chip-to chip interconnects at the board and back plane level.

(U) Program Plans:

- High-linear density, low loss optical data transport channels that can be routed to ~1 meter distance in a geometric form factor compatible with a printed circuit board.
- High speed (faster then 10 GBps), low power (less then 50 mW) optical transmitter/receivers.
- Integration of optical transmitters/receivers and optical data paths with electronic packaging and manufacturing approaches.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Photonic Circuits	0.000	0.000	3.000	5.815

(U) This program will develop two critical alternative photonic technologies based on silicon substrates. The first thrust addresses active photonic components based on silicon which do not rely on generating light within the material. While passive photonic components, such as waveguides, can be fabricated from silicon, silicon's indirect bandgap does not lend it to fabricating active photonic components based on the generation of photons (lasers, amplifiers etc.). The first alternative technology development will be optical amplifiers using Raman gain. Fiber amplifiers based on Raman gain currently play a major role in optical networks, and demonstrating this optical amplification in silicon will be a major step toward overcoming on chip losses in complex chip-scale optical components. The second alternative technology development will address optical transistor action, or switching, in silicon, (i.e., a three-terminal optical device, in which control photons at one terminal will make a

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large change in the photons transmitted between the other two terminals). Taken together, these two capabilities will create a new paradigm, in which silicon will provide a platform for monolithic integration of photonic and electronic functions.

(U) Program Plans:
- Demonstrate low-loss waveguides connecting optical gates.
- Demonstrate increased dynamic range for the logic gates.
- Demonstrate integrated processing functions such as adders and shift registers, requiring integration of 3-10 logic gates.

	FY 2002	FY 2003	FY 2004	FY 2005
High Frequency Wide Band Gap Semiconductor Electronics Technology	24.150	20.431	19.970	16.000

(U) The High Frequency Wide Band Gap Semiconductor Electronics Technology program is developing wide band gap semiconductor technology and will demonstrate high performance, cost effective high power electronic devices that exploit the unique properties of wide band gap semiconductors. This program will develop low defect epitaxial films, high yield fabrication processes, and device structures for integrated electronic devices for emitting and detecting high power radio frequency/microwave radiation, and high power delivery and control.

(U) Program Plans:
- Develop bulk and surface process technologies for reducing or mitigating crystallographic defects in wide band gap materials.
- Develop semi-insulating substrates for high frequency devices.
- Design high power enclosures for microwave electronic assemblies.
- Demonstrate large periphery high power devices suitable for microwave and mm-wave operation.
- Demonstrate process reproducibility and minimization of yield limiting factors.
- Establish device characterization for very high power solid-state amplifiers.
- Demonstrate 100 mm SiC and wide band gap alternate substrates with less than 80 micropipe/cm^2 and resistivity 10^6 ohms-cm.
- Demonstrate epitaxial processes that yield + 3 percent uniformity over 75 mm wide bandgap substrates.
- Initiate thermal management study to determine best packaging approach for high power, high frequency microwave and millimeter wave transistors.

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- Demonstrate 100 mm SiC and wide band gap alternate substrates with less than 40 micropipe/cm^2 and resistivity 10^7 ohms-cm.
- Demonstrate epitaxial processes that yield + 1 percent uniformity over 100 mm wide bandgap substrates.
- Identify fabrication processes for robust microwave and mm-wave devices. Identify thermal management concepts to sustain more than 1 KW/cm2 power density in high power devices.
- Optimize wide band gap semiconductor materials to achieve 100 mm substrates with less than 10 micropipe/cm^2 and resistivity greater than 10^7 ohms-cm at room temperature.
- Demonstrate fabrication processes for robust microwave and mm-wave devices with RF yields greater than 70 percent.
- Demonstrate thermal management concepts to sustain more than 1KW/cm^2 power density in high power devices.

	FY 2002	FY 2003	FY 2004	FY 2005
High Power Wide Band Gap Semiconductor Electronics Technology	11.951	7.999	12.140	14.000

(U) An initiative in High Power Wide Band Gap Semiconductor Electronics Technology will develop components and electronic integration technologies for high power, high frequency microsystem applications based on wide band gap semiconductors.

(U) Program Plans:

- Develop low defect conducting Silicon Carbide (SiC) substrate consistent with yielding 1 cm^2 devices.
- Develop lightly doped, thick (more than 100 micron) SiC epitaxy with low defects to enable 10 kV class power devices.
- Develop low on-state resistance SiC diodes capable of blocking 10 kV.
- Demonstrate SiC wafer and thick epitaxy with less than 1.5 catastrophic defects per cm^2 consistent with 10 kV reverse blocking.
- Initiate work on Megawatt class SiC power device able to switch at more then100 kHz.
- Initiate work on packaging of high power density, high temperature SiC power electronics.
- Demonstrate megawatt Class SiC power devices.
- Demonstrate high power density packaging for greater than 10 kV operation.
- Develop integrated power control logic compatible with high temperature and power SiC power devices.

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	FY 2002	FY 2003	FY 2004	FY 2005
Smart Power Based On Heterogeneous Integration of Si and SiC Electronics	0.000	0.000	6.686	8.000

(U) The Smart Power Based on Heterogeneous Integration of Silicon and Silicon Carbide Electronics program will develop the technology to monolithically or heterogeneously integrate Si/SiGe-on-SiC and/or SiC-on-Si/SiGe, develop new device and circuit concepts to optimize converter performance, and develop optimized kW-class power converters for various of DoD electronics applications.

(U) Program Plans:

- Perform concept study to define opportunities for smart power and the potential for integrating silicon carbide, or other wide bandgap semiconductor, with silicon electronics.
- Identify key technical challenges and quantity impact of potential platforms.
- Identify compelling applications.
- Select and optimize wide bandgap materials and processes for smart power circuits.
- Develop integration techniques for silicon carbide, or other wide bandgap semiconductor, onto silicon and/or silicon onto silicon carbide.
- Develop low on-resistance, fast switching silicon carbide power devices with hybrid control electronics.

	FY 2002	FY 2003	FY 2004	FY 2005
Acoustic Micro-Sensors	5.802	0.000	0.000	0.000

(U) The Acoustic Micro-Sensors program demonstrated a miniature acoustic sensor system based on MEMS transducers and advanced non-linear signal processing techniques for three-dimensional detection, capture, and tracking of sound sources in noisy environments with optimum sensitivity.

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(U) Program Plans:

- Integrated MEMs-based three-dimensional acoustic transducer array with read-out electronics.
- Demonstrated acoustic microsystem for remote detection and tracking of voices or sound sources in noisy outdoor environments.

	FY 2002	FY 2003	FY 2004	FY 2005
Materials Integration on Silicon	7.997	0.000	0.000	0.000

(U) The Materials Integration on Silicon program demonstrated technologies and applications of direct integration of advanced materials and devices, such as high-speed logic and RF transistors with semiconductor integrated circuits.

(U) Program Plans:

- Demonstrated heterogeneous fabrication processes and technologies for integrating disparate semiconductor devices and materials.
- Completed fabrication of composite microcircuits that demonstrate advanced capabilities through the incorporation of devices from multiple materials.
- Evaluated feasibility of flexible, mobile, high-resolution display components for wireless communications.

	FY 2002	FY 2003	FY 2004	FY 2005
Reconfigurable Aperture (RECAP)	6.236	0.000	0.000	0.000

(U) The Reconfigurable Aperture (RECAP) program provided revolutionary antenna technology for future military needs in high capacity communications and sensors. Technologies advanced include: artificial magnetic conductors, radio frequency (RF) MEMS switches, photonic band gap ground planes, high-density multi-layer interconnects and fragmented antennas. These were integrated into demonstrations that showed substantial new capabilities such as multi-beam arrays for communication and multi-band radar links that electronically reconfigure to provide near-hemispherical coverage. Applications such as the Future Combat System need such battlefield links. Wideband antenna technologies allow simultaneous Electronic Support Measures and radar functions from a single aperture. Finally, this technology allows the number of antennas on aircraft and ships to be reduced by a factor of 5 – 10.

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(U) Program Plans:
- Integrated and assembled component technologies into single sub arrays, which replace multiple antenna systems.
- Developed and demonstrated low cost fabrication processes to support technology transition.
- Initiated demonstrations of applications in low band communications, ELINT/SIGINT and multiband radar.
- Completed validation of Renoir modeling and simulation software.
- Used Renoir model to estimate impact of RECAP technologies on existing and future antenna systems.
- Completed demonstrations.

	FY 2002	FY 2003	FY 2004	FY 2005
Fabrication of 3D Structures	1.400	2.341	0.000	0.000

(U) The Fabrication of Three Dimensional Structures program investigated multi-chip module technology.

(U) Program Plans:
- Continue development of key technologies behind a packaging concept that uses a stacked multi-chip module approach to reduce interconnect length and increase physical connectivity between layers of electronics.

	FY 2002	FY 2003	FY 2004	FY 2005
Center for Optoelectronics and Optical Communications	2.000	4.876	0.000	0.000

(U) The Center for Optoelectronics and Optical Communications program will investigate advances in optical communications.

(U) Program Plans:
- Continue optoelectronic and optical communications development.

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	FY 2002	FY 2003	FY 2004	FY 2005
Center for Integrated Technologies (CIT)	5.000	0.000	0.000	0.000

(U) The Center for Integrated Technologies (CIT) program focused on basic and applied research outcomes to incubate new and existing commercialization opportunities of photonic devices and materials. CIT will support the vision to be a catalyst for promoting sustainable economic development and growth in Western North Carolina. The long-term objective is aimed at photonics manufacturing focusing on design for manufacturability, quality, reliability of devices, increased producibility, and increased yields of devices and components.

(U) Program Plans:

- Created an undergraduate program for training technical manpower needed for volume manufacturing of advanced photonic components.
- Developed designs for fiber optic connectors that are capable of submicron precision and yet are amenable to volume production at very low cost.
- Developed designs for the next generation (for 10 G Ethernet) optical transmitter/receiver modules.

	FY 2002	FY 2003	FY 2004	FY 2005
Boron Energy Cell	2.000	0.000	0.000	0.000

(U) The Boron Energy Cell effort investigated the use of Boron Energy Cell technology that uses radiation hardened semiconductor materials and radioactive isotope energy sources to support advanced DoD technology applications in long duration power generation and self-powered electronics.

(U) Program Plans:

- Developed the science and technology base for boron energy cells.

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	FY 2002	FY 2003	FY 2004	FY 2005
Nanostructured Photonic and Biomedical Materials	0.000	0.974	0.000	0.000

(U) Program Plans:

– Self assembly chemistry will be used to prepare new materials for applications in spintronics and bio-inspired optics.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Cryogenic Electronics MPT-06	7.823	4.149	4.911	9.808	14.678	16.611	19.523	19.504

(U) **Mission Description:**

(U) Thin-film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military systems. Films may be deposited and patterned to form electromagnetic components in ways that are similar to, and compatible with, the processes of conventional semiconductor manufacturing. Such electromagnetic components, as well as complementary metal oxide semiconductors (CMOS), work best at lower temperatures, so that cryogenic packaging generally will be required for optimum performance. Thin-film high temperature superconducting (HTS) components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance by more than an order of magnitude while reducing size and power requirements. Particular demonstrations include detection and geolocation of targets of high interest based upon low-level characteristic emissions and communications receivers with greater immunity to interference. Highly dependable and inexpensive cryocoolers are also being developed for these applications. These latter development efforts include the exploration of techniques to improve the performance of solid-state thermoelectric materials and devices in applications ranging from communications to power generation.

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

	FY 2002	FY 2003	FY 2004	FY 2005
Totally Agile Sensor Systems (TASS)	7.823	4.149	0.000	0.000

(U) The sensitivity of a standard radio receiver for the detection of small signals in an interfering background can be enhanced up to 10X, by the insertion of a high temperature super conducting (HTS) filter at the input of the receiver. Such ultra-sensitive receivers, mounted on military aircraft, ships and ground installations, have proven to be highly effective for SIGINT and COMINT missions. The Totally Agile Sensor Systems (TASS) program has demonstrated frequency tunability of HTS filters up to 30% of base frequency, thereby providing greater agility to cover the frequency spectrum. The final phases of the TASS program are directed toward enhancing performance even further in terms of sensitivity and

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selectivity, by narrowing the bandwidth of the HTS filter by 10-100X, while maintaining tunability. Such capability will vastly improve overhead SIGINT collection in a spectrally-crowded environment.

(U) Program Plans:
- Fabricate novel HTS filters with ultra-high quality factor (Q) and 0.1% bandwidth.
- Incorporate agile front-end pre-selector modules utilizing tunable high-Q HTS filters within standard receivers.
- Demonstrate totally agile sensor systems with ten times SIGINT and COMINT capability.
- Transition capability for 30 percent tunability to RC-135 aircraft demonstration.
- Adapt ultra-high Q and tunability for demonstration in a receiver console, with features for sweep rate and filter reconfiguration.

	FY 2002	FY 2003	FY 2004	FY 2005
Rapid Identification and Targeting (RAPIT)	0.000	0.000	4.911	9.808

(U) The goal of the RAPIT program is to develop a method of detection, identification and location of hidden threat forces which are not emitting radiation and are not discernable by present technical means. In the context of a network centric model, utilizing lightweight and lightly-armored systems, a probable threat is a foot soldier (dismount) with a rocket propelled grenade or similar weapon. Since it is likely that he will be carrying a radio or other communications gear, it is possible to detect and identify the radio by (1) its emission in standby mode (leakage), or (2) an induced nonlinear RF return if appropriately stimulated (stimulated leakage), even when the radio is unpowered. Both these techniques were originally demonstrated within the DARPA TASS program utilizing RF receivers with tunable HTS front-end filters. Only tunable HTS front-end filters have the necessary sensitivity and selectivity for low-level RF signals detection. Detection ranges of over 2 Km are possible in the near-term. The RAPIT technique will be fully developed and quantified for all likely threats, and a targeting system will be assembled.

(U) Program Plans:
- Measure radio frequency emission characteristics of generic components, active and passive modes, on bench top and in anechoic chambers.
- Determine range projections for target detection, based upon initial measurements and likely scenarios.
- Evaluate clutter, intermodulation distortion and propagation effects on targeting.

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- Demonstrate detection of specific targets from an airborne platform.
- Evaluate detection and geolocation of multiple targets and target classes.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Beyond Silicon MPT-08	63.511	88.459	78.871	47.826	19.570	14.657	0.000	0.000

(U) Mission Description:

(U) The phenomenal progress in current electronics and computer chips will face the fundamental limits of silicon technology in the early 21st century, a barrier that must be overcome in order for progress to continue. The Beyond Silicon project explores alternatives to silicon based electronics in the areas of new electronic devices, new architectures to use them, new software to program the systems and new methods to fabricate the chips. Approaches include nanotechnology, nanoelectronics, molecular electronics, spin-based electronics, quantum computing, new circuit architectures optimizing these new devices, and new computer and electronic systems architectures.

(U) The Beyond Silicon project investigates the feasibility, design, and development of powerful information technology devices and systems using approaches to electronic device designs that extend beyond traditional Complementary Metal Oxide Semiconductor (CMOS) scaling, including non-silicon based materials technologies, to achieve low cost, reliable, fast and secure computing, communication, and storage systems. This investigation is aimed at developing new capabilities; from promising directions in the design of information processing components using both inorganic and organic substrates, designs of components and systems leveraging quantum effects and chaos, and innovative approaches to computing designs incorporating these components for such applications as low cost seamless pervasive computing, ultra-fast computing, and sensing and actuation devices.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Quantum Information Science and Technology (QuIST)	15.386	20.597	27.268	23.879

(U) The Quantum Information Science and Technology (QuIST) program will explore all facets of the research necessary to create a new technology based on quantum information science. Research in this area has the ultimate goal of demonstrating the potentially significant advantages of quantum mechanical effects in communication and computing. Technical challenges include loss of information due to quantum

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decoherence, limited communication distance due to signal attenuation, limited selection of algorithms and protocols, and scalability to large numbers of bits. Error correction codes, fault tolerant schemes, and longer decoherence times will address the loss of information. Signal attenuation will be overcome by exploiting quantum repeaters. New algorithm techniques and complexity analysis will increase the selection of algorithms, as will a focus on signal processing. Scalable solid-state technologies will integrate thousands of qubits on a single device. Expected impacts include highly secure communications, algorithms for optimization in logistics and wargaming, highly precise measurements of time and position on the earth and in space, and new image and signal processing methods for target tracking.

(U) Program Plans:

- Determine quantum architecture and design solutions for problems such as graph isomorphism, imaging, and signal processing.
- Investigate alternative protocols for secure quantum communication, quantum complexity, and control.
- Investigate the use of quantum information in metrology.
- Demonstrate improved single and entangled photon sources and detectors.
- Investigate alternative designs, architectures and devices for quantum communication, computation, and memory; demonstrate low overhead, fault tolerant solid state quantum bit (qubit) memory and gates with at least two entangled qubits.

	FY 2002	FY 2003	FY 2004	FY 2005
Polymorphous Computing Architecture	13.266	14.942	16.992	13.574

(U) The Polymorphous Computing Architectures program is developing a revolutionary approach to the implementation of embedded computing systems to support reactive multi-mission, multi-sensor, and in-flight retargetable missions, and reduce payload adaptation, optimization, and verification from years to days to minutes. Current DoD embedded computing systems can be characterized as static in nature, relying on hardware-driven, heterogeneous point-solutions that represent static architectures and software optimizations. The program breaks the current development approach of hardware first and software last by moving beyond conventional silicon to flexible polymorphous computing systems. The key efforts of this revolutionary step forward in embedded computing systems are: 1) define critical reactive computing requirements and critical micro-architectural features; 2) explore, develop and prototype reactive polymorphous computing concepts; 3) explore, develop and prototype multi-dimensional verification and validation techniques for dynamic reactive missions; and 4) provide early experimental testbeds and prototype polymorphous computing systems. The result will be an embedded computing processing capability that will be mission and technology invariant yet highly optimizable for each new mission instantiation, thus providing for tactical and strategic mission tempo

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opportunities as well as technical upgradeability over the life of the computing system. Based on an average of four major upgrades over a 30 year period, significant saving of up to 45 percent in development and deployment costs may now be achieved over the life of a typical DoD embedded computing system.

(U) Program Plans:
- Characterize and perform functional decomposition of pivotal reactive system algorithms and computing functions.
- Develop multi-dimensional reactive computing optimization, verification techniques.
- Model, simulate and characterize complete candidate polymorphic computing systems including hardware elements, morphware, run-time systems, and tools.
- Perform early small scale proof-of-concept testing, integration and evaluation of early polymorphic computing architecture prototypes.
- Demonstrate and quantify the potential of full up polymorphic computing architecture systems for the DoD and their complementary commercial viability.
- Select, develop, and perform a DoD risk reduction effort for a multi-mission application.

	FY 2002	FY 2003	FY 2004	FY 2005
Antimonide Based Compound Semiconductors (ABCS)	10.979	14.870	9.346	0.000

(U) Included within this project is a program to develop low power high frequency electronics circuits and infrared (IR) sources based on the Antimonide family of compound semiconductors (ABCS). Specific IR source goals include operating above thermoelectric cooled temperatures and greater than 10 percent efficiency with continuous wave (cw) in the Mid-Wave Infrared (MWIR) and single mode cw operation in the Long-Wave Infrared (LWIR).

(U) Program Plans:
- Substrate Technology. Accelerate recent breakthroughs in lateral epitaxial overgrowth and thin film delaminating and rebonding to develop a source for ABCS substrates with essentially any desired thermal and/or electronic property.
- Electronics Integration. Raise levels through a series of demonstrations of analog, digital or mixed signal circuits with increasing device count which have beyond state-of-the-art performance in terms of frequency of operation and low power consumption.
- Demonstrate robust semi-insulating ABCS substrate material.

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- IR sources. Exploit the unique bandgap engineering approaches available with the ABCS family of materials to increase the operation temperature above 230 degrees Kelvin and extend emission over the Long-Wave Infrared (LWIR) range.
- Achieve multi-watt output, array technology along with increases in efficiency for individual devices.
- Deliver first six multi-batch ABCS substrates.

	FY 2002	FY 2003	FY 2004	FY 2005
Integrated Mixed Signal (A/D) and Electronic/Phototonic Systems (NeoCAD)	10.857	15.529	8.987	0.000

(U) The Integrated Mixed Signal (A/D) and Electronic/Photonic Systems (NeoCAD) program will develop and demonstrate innovative approaches to Computer Aided Design (CAD) of Mixed Signal (Analog/Digital) and Mixed Electronic/Photonic systems. The goal is to enable the design and prototyping of ultra complex microsystems with a high degree of integration and complexity for both military and commercial applications.

(U) Program Plans:

- Develop Model Order Reduction methods (for analog and photonic devices) to enable the creation of behavioral models.
- Develop and demonstrate top-down design capabilities for analog, mixed signal and mixed electronic/photonic systems that match the efficiency currently achieved with digital designs.
- Develop fast solvers for analog and photonic devices; perform non-linear model order reduction, develop extraction tools, synthesis and layout capabilities for mixed signal and mixed electronic/photonic circuits, develop interfaces with existing digital tools to enable co-simulation.
- Demonstrate the tools for designing and prototyping selected mixed electronic/photonic circuits and mixed signal systems (e.g., Analog-to-Digital Converters) for military applications.
- Develop a design methodology for analog, mixed signal and mixed electronic/photonic systems utilizing:
  - Analog behavioral models in a digital design environment.
  - Extraction methodogies for analog and photonic devices.
  - Synthesis and layout rules for analog and photonic devices.
  - Hierarchical design libraries.

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	FY 2002	FY 2003	FY 2004	FY 2005
Moletronics	13.023	22.521	11.330	0.000

(U) The molecular electronics (Moletronics) program is demonstrating the integration of multiple molecules, nanotubes, nano-wires, etc., into scalable, functional devices that are interconnected to the outside world with the potential to provide low power, a wide range of operating temperatures and much greater device density. This research will also demonstrate the scalability of molecular scale electronics to circuits containing 10^{11} elements and for densities equivalent to $10^{11}/cm^2$ and show that hierarchical self-assembly processes can be employed to build molecular circuits.

(U) Program Plans:

- Characterize and optimize molecular-based devices such as switches, multi-state molecules and molecules exhibiting highly non-linear characteristics such as negative differential resistance.
- Demonstrate that nano-wires have conductivities near that of bulk metal or better.
- Quantify the defect-tolerance required for a molecular-based computer to still function.
- Develop hierarchically directed assembly processes to assemble molecular devices, wires and interconnects.
- Demonstrate efficient defect-search algorithms.
- Model the scalability of molecular circuit architectures to high counts and high device densities.

	FY 2002	FY 2003	FY 2004	FY 2005
Molecular Computing	0.000	0.000	4.948	10.373

(U) The goal of the Molecular Computing program is to extend the capabilities being developed in the current Moletronics program to demonstrate the computational processing capabilities of molecular electronics in a system that integrates memory with control logic and data paths. A demonstration processor will be designed and built that can interpret a simple high-level language. This approach will allow the use of a simpler processor designs to demonstrate the advantages of nano-scale molecular electronics that do not have the conventional circuitry overhead associated with modern pipeline chip designs.

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(U) Program Plans:

- Construct combinatorial logic functions assembled from molecular-scale components.
- Use small-scale integration (SSI) to build combinatorial logic functions using molecular-scale components.
- Construct sequential logic/Finite-state machine assembled from molecular-scale components.
- Add registers or latches in communication with combinatorial logic arithmetic functions.
- Use medium-scale integration (MSI) to construct sequential logic/finite-state machine assembled from molecular-scale components.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Biologically Based Materials and Devices MPT-09	0.000	85.081	84.674	88.858	86.402	78.169	78.093	78.017

(U) Mission Description:

(U) This project acknowledges the growing and pervasive influence of the biological sciences on the development of new materials and devices as well as the commensurate influence of materials, physics and chemistry on new approaches to biology and biochemistry. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the development of biochemical materials for enhancement of performance, the development of multifunctional transducers based on biological membranes, and the application of magnetic materials in biological applications. This project contains efforts originating in Projects MPT-01, MPT-02 in this PE and maturing technologies from PE 0601101E, Project BLS-01. For convenience, FY 2002 accomplishments for those efforts are presented in this project.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Bioinspired and Bioderived Materials	0.000	35.081	33.000	32.758

(U) The Bioderived Materials thrust explores the application of biomimetic principles to materials and devices of interest to the DoD. Specifically, the unique characteristics of biologically derived materials and devices will be exploited through understanding, control and emulation of the structure and chemistry of the interface between man-made and biotic materials. This includes an effort to develop synthetic optics that mimics the advantages and adaptability of biological lenses. Other efforts seek to understand the principles of locomotion and sensing capabilities of biological organisms and implement them in man-made materials for robotics and other Defense applications. Also, the fundamental operating principles of biomolecular motors will be developed and exploited for designing nano- to macro-scale devices having unparalleled energy efficiency. Finally, the physical interfaces necessary for interacting and controlling biology will be developed and exploited.

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(U) Program Plans:

- Explore soft materials (e.g., actuators, adhesives) in biological systems for potential Defense applications.
- Demonstrate biomimetic sensory prototypes that collect electromagnetic olfactory and visual inputs.
- Define new materials for coordinated appendage function in land and air platforms that utilize biomimetic principles of locomotion and actuation.
- Explore new bioinspired locomotion in robotic systems and develop power efficient, systems level bio-locomotion for mobility in rough terrain.
- Demonstrate a material system based on bio-inspired optics technology that can produce a reversible change in the index of refraction of 1.0 point over a bandwidth of at least 50 nanometers with 95% or better transmittance allowing a re-configurable optical system that is capable of changing between wide angle (120 degrees) and narrow field of view within a frame rate.
- Develop bio-inspired optical components and filters based on novel materials chemistry and unique hierarchical structure.
- Determine and quantify the mechanism of motor function, motor performance, and efficiency for several types of biomolecular motors through computational models and experimental measurements.
- Isolate, modify, and integrate biomolecular motors with synthetic/inorganic materials to demonstrate devices with unique energy conversion capabilities and potential DoD utility.
- Exploit animal sentinels, including the development of critical materials/device interfaces to address teleoperation and autonomous navigation, for their ability to be remotely guided to operationally relevant sites and generate environmental information (chemical, biological, visual).

	FY 2002	FY 2003	FY 2004	FY 2005
Biochemical Materials	0.000	38.000	35.000	35.000

(U) The Biochemical Materials thrust examines how breakthroughs in the understanding of biochemistry can drastically improve the capabilities of soldiers. For example, examining the biochemistry of the brain during sleep deprivation can lead to new approaches in enhancing performance in soldiers. The application of biochemical principles can also lead to understanding the physiology of the solider as he/she heads for battle and to developing techniques to allow the principles of biological organisms that survive in extreme environments to be exploited for the preservation of tissue and cells of interest to DoD.

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(U) Program Plans:
- Demonstrate induced desiccation strategies for platelets that allow over 13 months of dry storage and recovery.
- Develop self-care medical technology to enable the warfighter in the battlefield to accelerate wound healing, internal clotting and pain relief to maintain a functional soldier.
- Develop an understanding of the biochemical and physiological causes of decreased cognitive performance during sleep deprivation through studying animal model systems, synaptic function, and transcranial magnetic stimulation (TMS).
- Demonstrate and validate approaches to develop biomaterials and other concepts that extend the cognitive performance capabilities of warfighters during extended periods of sleep deprivation and stress.
- Develop methods for enhancing functional and physiokinetic endurance by nutritional, pharmaceutical and physical methods that are rapidly inducible, reversible and minimize the need for caloric intake while enhancing both strength and endurance.
- Develop methods for regulating core body temperature that enhance physical performance and endurance.
- Demonstrate the capability to transfer biochemical processes chemically or physically to cells lacking robust survival mechanisms.
- Understand pathways and develop biomedical technology required to enhance spatial orientation of the warfighter.

	FY 2002	FY 2003	FY 2004	FY 2005
Responsive Membrane Devices (REMEDE)	0.000	7.000	5.674	3.500

(U) The goal of the Responsive Membrane Devices (REMEDE) program is to engineer biomimetic membrane technology and other biomimetic concepts necessary for the emulation of the critical biochemical functions found in nature. An important underlying technology supporting this thrust is the ability to rapidly identify the underlying biological materials and structures, particularly the ability to rapidly identify DNA/RNA/protein structures for potential use or optimization in subsequent processes. Specifically, this program will develop and demonstrate approaches for manufacturing a variety of materials (proteins, polymers, etc.) with the specificity found in nature at the scale of manufacture useful for Defense.

(U) Program Plans:
- Develop membrane based, micro-reactors and related nanotechnologies that will emulate and scale up the precise biochemical and chemical processes capabilities of biology.
- Demonstrate the production of ultra-high purity materials of interest to DoD including proteins and organic compounds.

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- Demonstrate feasibility of single molecule DNA/RNA/protein sequencing towards a tool for bioinspired materials and process engineering.

	FY 2002	FY 2003	FY 2004	FY 2005
Bio-Magnetic Interfacing Concepts (BioMagnetICs)	0.000	5.000	6.000	8.000

(U) The Bio-Magnetic Interfacing Concepts (BioMagnetICs) Materials program will develop and demonstrate novel capabilities for integrating nanomagnetics with biology and will demonstrate the advantages of magnetics as a powerful new transduction mechanism for detecting, manipulating, and controlling biological function in single cells and biomolecules. The state-of-the-art research "tools" that have allowed researchers to observe the most fundamental units of biology (cells, DNA, proteins, etc.) do not possess the resolution, precision, or high throughput capacity to enable manipulation and/or functional control of large numbers of cells and biomolecules. Such a capability would have a pervasive and paradigm shifting impact on future military and civilian applications of biotechnology including chem-bio detection, therapeutics, and medical diagnostics. Nanoscale magnetics offers the promise of a robust, non-invasive, non-destructive, multiplexing, and high throughput interface that is compatible with the nanometer scale at which the biochemistry of cellular function exists.

(U) Program Plans:

- Develop and demonstrate a portable, magnetics-based DNA detection and readout capability for human identification and biodetection.
- Develop and demonstrate a capability for non-invasive, non-destructive imaging of intracellular activity.
- Develop and demonstrate remotely addressable, magnetics-based biochemical sensors.
- Develop and demonstrate the capability to magnetically manipulate and actuate cellular functions such as apoptosis, reproduction, and gene expression.
- Develop and demonstrate the capability to use magnetics to rapidly filter biotoxins from humans.

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	FY 2002	FY 2003	FY 2004	FY 2005
Energy from Bio Systems	0.000	0.000	5.000	9.600

(U) The Energy from Bio Systems program will provide a power source for systems requiring long-term operational endurance as well as fast start-up times for systems that require immediate power. A liquid-fuel, biocatalytic fuel cell is being developed as one potential new energy source (for underwater applications in particular). Enzymes yield controlled reactions and products and recent advances in enzyme immobilization make them an attractive new electrode material. Many enzymes have kinetic constants orders of magnitude above metal catalysts for identical reactions, specifically with hydrogen peroxide and methanol.

(U) Program Plans:

- Identify methods of bioelectrocatalyst immobilization.
- Evaluate methods of mediator-less electron transport, and candidate molecules that act with peroxidase-like activity.
- Evaluate electrolyte-electrode-bioelectrocatalyst interactions and superstructures, and develop advancements in polymer science for electrode fabrication.
- Design bioelectrocatalysts that are compatible to both the environment of the fuel cell, the electrolyte, and electron transport to the electrode.
- Develop a proof-of-concept prototype biocatalytic (immobilized enzyme), liquid-phase fuel cell.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	131.954	235.300	323.730	340.567	346.978	385.281	380.120	381.014
Advanced Aerospace Systems ASP-01	131.954	124.783	114.357	109.847	98.372	63.512	33.190	0.000
Space Programs and Technology ASP-02	0.000	110.517	209.373	230.720	248.606	321.769	346.930	381.014

(U) Mission Description:

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

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

(U) Also funded within the Advanced Aerospace Systems project are several unmanned combat air vehicles. The Unmanned Combat Air Vehicle program continues to focus on risk reduction and "Concept of Operation" evaluation. The goal of the Naval Unmanned Combat Air Vehicle program is to validate the technical feasibility for a naval unmanned combat air system to effectively and affordably perform naval Suppression of Enemy Air Defense/Strike/Surveillance missions. The goal of the Unmanned Combat Armed Rotorcraft program is to design, develop, integrate and demonstrate the enabling technologies and system capabilities required to perform mobile strike concept of operations.

(U) The Space Programs and Technology Project is developing a space force structure that will be robust against attack. In addition to the ability to detect and characterize potential attacks, robustness against attack is provided by proliferation of assets, ready access to space and a flexible infrastructure for maintaining the capabilities of on-orbit assets. Ready access to space allows the delivery of defensive systems and

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replenishment supplies to orbit. An infrastructure to service the mission spacecraft allows defensive actions to be taken without limiting mission lifetime. The Orbital Express Space Operations Architecture program will develop and demonstrate autonomous techniques for on-orbit refueling and reconfiguration of satellites that could support a broad range of future U.S. national security and commercial space programs. The Space Surveillance Telescope program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. The Innovative Space-Based Radar Antenna Technology program addresses the technical and economic feasibility of developing space-based radar antennas necessary for tactical-grade ground moving target indicator performance from space. Deep view is developing a high-resolution radar imaging capability to characterize objects in the earth's orbit. The Responsive Access, Small Cargo, and Affordable Launch program will develop and demonstrate the capability to launch small satellites and commodity payloads into low-earth orbit. The High Frequency Active Auroral Research Project (HAARP) will develop new experimental research capabilities to exploit emerging ionosphere and radio science technologies related to advanced defense applications.

(U) An outgrowth of the space vehicle technologies and Hypersonics (TT-03) initiatives, the HyperSoar program will develop a dual use capability of an intercontinental global delivery vehicle and a first stage reusable space access vehicle. The Rapid On-orbit Anomaly Surveillance and Tracking program seeks to provide a space-based capability to detect and track on-orbit objects with rapid revisit rates and low latencies. The Low Cost Tactical Imager program will develop a spacecraft to provide high resolution imaging day or night using extremely lightweight optics and a compact design capable of being launched on a Pegasus air launch booster. The Tactical Pointing Determination of Imaging Spacecraft program will develop relocatable space surveillance radar to provide near-real time pointing determination of imaging spacecraft to the warfighter.

(U) **<u>Program Change Summary:</u>** *(In Millions)*

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	153.700	246.000	394.662	485.549
Current President's Budget	131.954	235.300	323.730	340.567
Total Adjustments	-21.746	-10.700	-70.932	-144.982

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	FY 2002	FY 2003
Congressional program reductions	-16.632	-14.900
Congressional increases	0.000	4.200
Reprogrammings	-0.114	0.000
SBIR/STTR transfer	-5.000	0.000

(U) Change Summary Explanation:

FY 2002	Decrease reflects inflation reduction; Section 8135 and Section 313 reductions.
FY 2003	Decrease reflects congressional program reductions and adds for Suborbital Space Launch and the Hummingbird UAV.
FY 2004-05	Decrease reflects reprioritization of various aerospace efforts and rephasing of several planned space programs.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Aerospace Systems ASP-01	131.954	124.783	114.357	109.847	98.372	63.512	33.190	0.000

(U) Mission Description:

(U) The Advanced Aerospace Systems project addresses high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems and provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Air Vehicle: A160 Hummingbird Warrior	12.824	12.627	11.377	8.421

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

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(U) Program Plans:
- Fabricate and test low vibration rotor modifications.
- Continue ground and flight test of A160 vehicles.
- Integrate/demonstrate electro-optic/infrared surveillance payload.
- Develop concept design of an unmanned ground vehicle deployment system for A160 vehicle.
- Perform conceptual design and trade studies of A160 variants for a variety of mission roles, including study of technology risk reduction, architecture, survivability, and command and control.
- Fabricate forward pass mini control station.
- Demonstrate forward pass operations with Electro-Optic/Infrared sensor.
- Flight test low vibration four-blade rotor modifications.
- Develop advanced airframe helo modification.
- Investigate application of the optimum speed rotor concept to tilt rotor aircraft, including conceptual design of an unmanned system.
- Conduct tests of advanced engines and coordinate with development of high-efficiency heavy fuel engine technologies.

	FY 2002	FY 2003	FY 2004	FY 2005
Unmanned Combat Air Vehicle (UCAV)	60.000	59.492	0.000	0.000

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

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(U) Program Plans:

- Develop and demonstrate core UCAV functionality.
- Coordinate flight and intelligent multi-vehicle flight operations.
- Demonstrate interoperability with Manned Force Packages.
- Design and develop next iteration low observable (LO) robust prototypes.
- Deliver two robust prototype air vehicles and an updated mission control segment.
- Demonstrate production of affordable LO airframe.
- Demonstrate maintenance of LO airframe and apertures.
- Develop provisions for future growth as a robust baseline for operational aircraft.

	FY 2002	FY 2003	FY 2004	FY 2005
Naval Unmanned Combat Air Vehicle (UCAV-N)	10.368	21.527	0.000	0.000

(U) The goal of the Naval Unmanned Combat Air Vehicle (UCAV-N) science and technology program is to validate the technical feasibility for a naval unmanned combat air system to effectively and affordably perform naval Suppression of Enemy Air Defense (SEAD)/Strike/Surveillance missions within the emerging global command and control architecture. This initiative will investigate and validate the critical technologies, processes and system attributes associated with the development of a UCAV-N system. The proposed UCAV-N design will be suitable for aircraft carrier use; however, it will also stress maximum commonality with the Air Force UCAV. Analysis of the potential capability enhancements that would be realized by legacy force carrier air wing through the introduction of 12 to 16 multi-mission Strike, SEAD and Surveillance unmanned combat aircraft that are suitable for aircraft carrier use is currently being investigated. The program will also emphasize a low life cycle cost combat effective design.

(U) Program Plans:

- Conduct demonstrations of technologies, processes, and systems attributes to demonstrate the feasibility of a low observable UCAV-N system capable of routine operation from aircraft carriers.
- Develop a system capable of conducting maritime network centric warfare.

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- Initiate detailed design of a demonstrator aircraft.
- Complete detailed design and initiate construction of demonstrator aircraft.

	FY 2002	FY 2003	FY 2004	FY 2005
Joint Unmanned Air Vehicle (UCAV-J)	0.000	0.000	50.590	28.923

(U) DARPA, the Air Force and the Navy will participate in the Joint Unmanned Combat Air Vehicle (UCAV-J) System Demonstration Program (SDP) to demonstrate the technical feasibility, military utility, and operational value of a UCAV family of vehicles. The UCAV-J program will initially identify and assess the common requirements, design space and technology maturity levels that support development of an affordable family of vehicles. The overall goal of the UCAV-J SDP is to design, develop, integrate, and demonstrate the critical technologies, processes, and system attributes pertinent to an objective UCAV-J system that is responsive to service mission requirements. These mission requirements include the capability to effectively and affordably perform lethal and non-lethal Suppression of Enemy Air Defense (SEAD), strike and Surveillance missions. The UCAV-J will be interoperable within the emerging global command and control architecture. The Air Force UCAV SDP program is currently executing flight demonstrations with the X-45A air vehicle and is in the design phase for low observable robust prototypes. The Naval Unmanned Combat Air Vehicle (UCAV-N) science and technology program is currently validating the technical feasibility for a naval unmanned combat air system suitable for aircraft carrier use. Analysis is also being conducted of the potential capability enhancements that would be realized by a legacy force carrier air wing through the introduction of 12 to 16 multi-mission Strike, SEAD and Surveillance UCAV-J that are suitable for aircraft carrier use.

Program Plans:

- Support development of joint service mission and affordability goals through cost-performance tradeoff analysis consistent with technology maturation levels.
- Coordinate technology development roadmaps that are responsive to preferred Weapon System Concepts and development milestones resulting from Joint program objective system analysis.
- Continue high leverage technology maturation efforts in support of future UCAV-J development.
- Complete detailed design and initiate construction of demonstrator aircraft.
- Develop an updated common mission control segment.

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	FY 2002	FY 2003	FY 2004	FY 2005
Unmanned Combat Armed Rotorcraft (UCAR)	5.900	22.805	35.432	55.904

(U) The goal of the Unmanned Combat Armed Rotorcraft (UCAR) program is to design, develop, integrate and demonstrate the enabling technologies and system capabilities required to perform armed reconnaissance and attack missions within the Army's Objective Force system-of-systems environment. The enabling technologies are survivability, autonomous operations, command and control, and targeting/weapons delivery. A highly survivable UCAR system will prosecute enemy high value targets with relative impunity without placing a pilot in harm's way. UCAR's autonomous capabilities will enable effective teaming with manned systems and will eliminate the requirement for a dedicated ground control station. The UCAR capabilities will provide the Objective Force with the mobility, responsiveness, lethality, survivability, and sustainability required to ensure mission success. Specific objectives of the UCAR program include: development and demonstration of an effective, low total ownership cost design for the system; an air and ground-based command and control architecture for UCAR operations that does not require a dedicated ground control station; autonomous multi-ship cooperation and collaboration; autonomous low altitude flight; and system survivability.

(U) Program Plans:

- Complete the System Conceptual Design Review and the Demonstrator System Requirements Review.
- Prepare an initial risk management and mitigation plan and system capabilities document.
- Select up to two teams for Phase II, preliminary design.
- Continue system trades, effectiveness, and affordability analyses through modeling and simulation.
- Develop sufficient system concept fidelity to validate program goals and objectives.
- Complete the preliminary design and the Preliminary Design Review of the Demonstration System.
- Select one team for Phase III, System Demonstration.
- Initiate detailed design of the Demonstration System.
- Complete the Critical Design Review of the Demonstration System.
- Initiate fabrication of two UCAR Demonstrators.
- Perform component risk reduction demonstrations.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, Project ASP-01

	FY 2002	FY 2003	FY 2004	FY 2005
Quiet Supersonic Platform	1.092	4.800	0.000	0.000

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

(U) Program Plans:

- Perform technology validation for long-range supersonic aircraft having low noise signature.
- Perform trade-studies and mission utility analysis.
- Conduct integration experiments and demonstrations of enabling technologies.
- Initiate preliminary system designs of highly integrated supersonic long-range aircraft.
- Conduct flight tests to validate optimized vehicle configurations produce shaped sonic boom signatures.
- Perform wind tunnel testing of low drag technology in simulated flight environment.
- Initiate preliminary design of laminar flow control technology integrated into flight test vehicle.
- Perform computational fluid dynamics calculations and conduct low and high speed wind tunnel tests of flight test vehicle to assess safety of flight.
- Conduct critical design review and initiate parts fabrication.
- Conduct flight testing to validate low drag technology in real flight environment.

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	FY 2002	FY 2003	FY 2004	FY 2005
Orbital Express Space Operations Architecture	30.996	0.000	0.000	0.000

(U) The goal of the Orbital Express Space Operations Architecture program is to validate the technical feasibility of robotic, autonomous on-orbit refueling and reconfiguration of satellites to support a broad range of future U.S. national security and commercial space programs. Refueling satellites will enable frequent maneuvers to improve coverage, change arrival times to counter denial and deception, and improve survivability, as well as extend satellite lifetime. Electronics upgrades on-orbit can provide "Moore's Law" performance improvements and dramatically reduce the time to deploy new technology. In addition, a servicing satellite can act as a "mother-ship" for micro-satellites, supporting deployment and operations of micro-satellites for missions such as space asset protection. The Orbital Express advanced technology demonstration will design, develop, and test on-orbit a prototype servicing satellite (ASTRO), a surrogate next generation serviceable satellite (NextSat), and the SPAWN Space Awareness prototype micro-satellite escort, that will provide near-field space situation awareness for U.S. satellites deployed in geo-stationary orbits. SPAWN will be designed with a modular satellite bus architecture, enabling rapid integration of payloads for responsive launch. The elements of the Orbital Express demonstration will be tied together by non-proprietary satellite servicing interfaces (mechanical, electrical, etc.) that will facilitate the development of an industry wide on-orbit servicing infrastructure. NASA will apply the sensors and software developed for autonomous rendezvous and proximity operations to reduce risk on the Orbital Space Plane and to enable future commercial resupply of the International Space Station. Launch of the demonstration system is scheduled for March 2006 on the Air Force Space Test Program MLV-05 mission. Beginning in FY 2003, this program is funded in Project ASP-02, Space Programs and Technology.

(U) Program Plans:

- Develop and validate software for autonomous mission planning, rendezvous, proximity operations and docking.
- Design, fabricate, and test on-orbit robotic satellite servicing, including fuel and electronics transfer, deployment of and operations with a micro-satellite.
- Design, fabricate, and test on orbit a modular micro-satellite for protection of stationary satellites.
- Perform utility assessments of on-orbit servicing in conjunction with operational customers and plan for technology transition.

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	FY 2002	FY 2003	FY 2004	FY 2005
Deep View	4.070	0.000	0.000	0.000

(U) The Deep View program (formerly entitled the "Space Object Identification System") will develop a high-resolution radar imaging capability to characterize objects in earth orbit. A special emphasis will be placed on imaging small objects at orbits ranging from low-earth orbit to geo-stationary orbit. The system will be based upon a large aperture imaging radar system redesigned to operate at very high power over very broad bandwidth at W-band. Key technology development will focus on transmitters capable of providing the required power to image at deep-space ranges over full bandwidth and antenna design that maintains necessary form factor over a very large aperture. The capabilities emerging from this program will enable the classification of unknown objects, such as space debris, as well as the monitoring of the health and status of operational satellites. In FY 2003, this program is funded in Project ASP-02, Space Programs and Technology.

(U) Program Plans:
- Perform analysis of transmitter technology alternatives.
- Analyze antenna design requirements.

	FY 2002	FY 2003	FY 2004	FY 2005
Space Technologies	6.704	0.000	0.000	0.000

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

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(U) Program Plans:
- Initiated feasibility studies; developed conceptual designs and figures of merit for morphing/shape control of space vehicles.
- Developed multifunctional structure concepts for reducing weight, improving survivability and adaptively changing capability of space structures.
- Initiated design for integrated hybrid power module and quantify performance improvements in powering radio frequency, microwave and optical system.

	FY 2002	FY 2003	FY 2004	FY 2005
Canard Rotor/Wing (CRW)	0.000	2.600	14.763	14.912

(U) The Army, Navy, Air Force, and Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) air vehicles to support dispersed units. Canard Rotor/Wing (CRW) aircraft offer the potential for a high-speed, rapid response capability from a VTOL air vehicle with significant range and stealth improvements as compared to other VTOL concepts. Design, fabrication, ground and flight test of a scaled vehicle demonstrator will validate the stability and control system and aerodynamic performance required for vertical take-off, landing and hover via a rotating center wing that stops and locks in place for efficient high speed cruise. Following demonstration of the small scale vehicle, the program will proceed to design, development and demonstration of more operationally representative vehicles including manned aircraft. In FY 2002, this program was funded in PE 0602702E, Project TT-07.

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

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	FY 2002	FY 2003	FY 2004	FY 2005
Heavy Fuel Engine for A160	0.000	0.932	2.195	1.687

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

(U) Program Plans:

- Detail design of the engine.
- Demonstrate performance of prototype engine at 33% efficiency and 0.83 hp/lb.
- Demonstrate performance and reliability of optimized engine at 39% efficiency and 1.0 hp/lb.

(U) Other Program Funding Summary Cost:

Advanced Air Vehicle: Hummingbird Warrior	FY 2002	FY 2003	FY 2004	FY 2005
SOCOM	5.700	9.000	0.000	0.000

Unmanned Combat Air Vehicle (UCAV)	FY 2002	FY 2003	FY 2004	FY 2005
PE 0603333F, Air Force	18.903	17.608	0.000	0.000
PE 0604731F, Air Force	0.000	39.127	TBD	TBD
PE 0207256F, Air Force	0.000	0.000	TBD	TBD

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Unmanned Combat Armed Rotorcraft (UCAR)	FY 2002	FY 2003	FY 2004	FY 2005
PE 0602211, Project 47A, Army	6.000	10.000	0.000	0.000
PE 0603003, Project 313, Army	0.000	0.000	14.000	20.000

Orbital Express Space Operations Architecture	FY 2002	FY 2003	FY 2004	FY 2005
NASA	8.000	9.000	8.000	0.000

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, Project ASP-02			
COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Space Programs and Technology, ASP-02	0.000	110.517	209.373	230.720	248.606	321.769	346.930	381.014

(U) Mission Description:

(U) A space force structure that is robust against attack represents a stabilizing deterrent against adversary attacks on space assets. In addition to the ability to detect and characterize potential attacks, robustness against attack is provided by proliferation of assets, ready access to space, and a flexible infrastructure for maintaining the capabilities of on-orbit assets. Ready access to space allows the delivery of defensive systems and replenishment supplies to orbit. An infrastructure to service the mission spacecraft allows defensive actions to be taken without limiting mission lifetime. In addition, developing space access and spacecraft servicing technologies will lead to reduced ownership costs of space systems and new opportunities for introducing technologies for the exploitation of space. Systems development is also required to increase the interactivity of space systems, space-derived information and services with terrestrial users. Because of the increasing national importance of this area, and the expanded resource allocations devoted to it, a separate project, ASP-02, has been created.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Orbital Express Space Operations Architecture	0.000	39.565	55.110	45.100

(U) The goal of the Orbital Express Space Operations Architecture program is to validate the technical feasibility of robotic, autonomous on-orbit refueling and reconfiguration of satellites to support a broad range of future U.S. national security and commercial space programs. Refueling satellites will enable frequent maneuver to improve coverage, change arrival times to counter denial and deception and improve survivability, as well as extend satellite lifetime. Electronics upgrades on-orbit can provide regular performance improvements and dramatically reduce the time to deploy new technology on-orbit. In addition, a servicing satellite can act as a "mother-ship" for micro-satellites, supporting deployment and operations of micro-satellites for missions such as space asset protection and sparse aperture formation flying. The Orbital Express advanced technology demonstration will design, develop and test on-orbit a prototype servicing satellite (ASTRO), a surrogate next

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generation serviceable satellite (NextSat), and the Space Awareness (SPAWN) prototype micro-satellite escort, that will provide near-field space situation awareness for U.S. satellites deployed in geo-stationary orbits. SPAWN will be designed with modular satellite bus architecture, enabling rapid integration of payloads for responsive launch. The elements of the Orbital Express demonstration will be tied together by non-proprietary satellite servicing interfaces (mechanical, electrical, etc.) that will facilitate the development of an industry wide on-orbit servicing infrastructure. NASA will apply the sensors and software developed for autonomous rendezvous and proximity operations to reduce risk on the Orbital Space Plane and to enable future commercial resupply of the International Space Station. Launch of the demonstration system is scheduled for March 2006 on the Air Force Space Test Program MLV-05 mission. In FY 2002, this program was funded from PE 0603285E, Project ASP-01, Advanced Aerospace Systems.

(U) Program Plans:
- Develop and validate software for autonomous mission planning, rendezvous, proximity operations and docking.
- Design, fabricate, and test on-orbit robotic satellite servicing, including fuel and electronics transfer, deployment of and operations with a micro-satellite.
- Design, fabricate and test on orbit a modular micro-satellite for protection of U.S. geo-stationary satellites.
- Perform utility assessments of on-orbit servicing in conjunction with operational customers and plan for technology transition.

	FY 2002	FY 2003	FY 2004	FY 2005
Space Surveillance Telescope	0.000	3.966	9.000	17.000

(U) The Space Surveillance Telescope program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. The program will leverage recent advances in curved focal plane array sensor technology and novel optics design to build a telescope with a large aperture that provides detection sensitivity with a low-aberration wide field-of-view to provide rapid wide-area search coverage. This capability will enable ground-based detection of un-cued objects in space for purposes such as asteroid detection and other defense missions. In FY 2002, this program was funded from PE 0603762E, Project SGT-02, Aerospace Surveillance Technology.

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(U) Program Plans:
- Complete telescope design.
- Complete focal plane design.
- Fabricate and test first curved focal plane tile.
- Fabricate remaining sensor elements.
- Begin optics fabrication.

	FY 2002	FY 2003	FY 2004	FY 2005
Innovative Space-Based Radar Antenna Technology (ISAT)	0.000	14.873	39.800	48.000

(U) The Innovative Space-Based Radar Antenna Technology (ISAT) effort is building on the FY 2002 conceptual designs addressing the technical and economic feasibility of developing space-based radar antennas necessary for tactical-grade ground moving target indication performance from space using rigidized inflatable technologies – a potentially key enabling technology. Ultra-low cost, lightweight technologies offer the potential for developing and deploying extremely large apertures in space – including RF and possibly optical apertures. Antennas of 100 – 300 meters in length, if feasible and affordable, will enable the revolutionary performance required to conduct true tactical sensing from space. Two competing conceptual designs, including a detailed technical design, and focused testing of key design components such as flexible transmit/receive modules, thin-film solar cells, and membrane designs will be developed. Additionally, the program will conduct ground-based risk reduction experiments demonstrating the accuracy of the constitutive models for deployment and control of rigidized inflatable structures, and will develop performance predictions on the selected designs as well as lifecycle cost models. One design will be selected to carry out a space-based experiment, culminating in a demonstration of tactical targeting from space. In FY 2002, a series of studies and lab tests to prepare for this activity was funded in PE 0603762E, Project SGT-03, Air Defense Initiative.

(U) Program Plans:
- Develop next-generation lightweight electronics, materials and deployment structures.
- Perform ground-based risk reduction experiments for packaging and deployment mechanisms and materials, including simulation of mechanical and thermal loads.

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– Complete systems designs for space-based experiment; downselect to single design; build, integrate and demonstrate tactical targeting from space.

	FY 2002	FY 2003	FY 2004	FY 2005
Deep View	0.000	4.199	9.520	10.220

(U) The Deep View program (formerly entitled the "Space Object Identification System") will develop a high-resolution radar imaging capability to characterize objects in earth orbit. A special emphasis will be placed on imaging small objects at orbits ranging from low-earth orbit to geo-stationary orbit. The system will be based upon a large aperture imaging radar system redesigned to operate at very high power over very broad bandwidth at W-band. Key technology development will focus on transmitters capable of providing the required power to image at deep-space ranges over full bandwidth and antenna design that maintains necessary form factor over a very large aperture. The program will investigate the feasibility of designing a transportable version of such a system. The capabilities emerging from this program will enable the classification of unknown objects, such as space debris, as well as the monitoring of the health and status of operational satellites. In FY 2002, this program was funded in Project ASP-01, Advanced Aerospace Systems.

(U) Program Plans:

– Perform transmitter power combiner experiments.
– Complete transmitter design and radar system design.
– Begin signal processing software development.

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	FY 2002	FY 2003	FY 2004	FY 2005
Responsive Access, Small Cargo, Affordable Launch (RASCAL)	0.000	24.303	38.500	33.400

(U) The Responsive Access, Small Cargo, Affordable Launch (RASCAL) program will design and develop a low cost orbital insertion capability for dedicated micro-size satellite payloads. The concept is to develop a responsive, routine, small payload delivery system capable of providing flexible access to space using a combination of reusable and low cost expendable vehicle elements. Specifically, the RASCAL system will be comprised of a reusable airplane-like first stage vehicle called the reusable launch vehicle and a second stage expendable rocket vehicle. The RASCAL demonstration objectives are to place satellites and commodity payloads, between 50 and 130 kilograms in weight, into low-earth orbit at any time, with launch efficiency of $20,000 per kilogram or less. While the cost goal is commensurate with current large payload launch systems, the operational system, through production economies of scale, will be more than a factor of three less than current capabilities for the dedicated micro payload size. This capability will enable cost effective use of on-orbit replacement and re-supply and provide a means for rapid launch of orbital assets for changing national security needs. This program will utilize reusable aircraft technology for the first stage and will take advantage of low-cost rocket technologies for the expendable upper stages. With recent advances in design tools and simulations, this program will prudently reduce design margins and trade-off system reliability to maximize cost effectiveness. This program will also leverage advancements in autonomous range safety, first-stage guidance; and predictive vehicle health diagnosis, management and reporting to lower the recurring costs of space launch. In FY 2002, this program was funded from Project TT-06, Advanced Tactical Technology.

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

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– Integrate low cost expendable rocket vehicle and common head steering stage design.
– Develop instrumentation package for maiden payload.
– Conduct two orbital insertion missions for final demonstration.

	FY 2002	FY 2003	FY 2004	FY 2005
Low Cost Tactical Imager	0.000	3.472	12.210	15.000

(U) The Low Cost Tactical Imager (LCTI) program will develop an inexpensive, high-resolution, day/night imaging spacecraft able to be rapidly manufactured and launched on-demand, anywhere, into any orbit to support the tactical warfighter. LCTI will provide the first-ever ability to task the spacecraft and downlink the imagery in the same pass to support near real time imaging and targeting, perform rapid bomb damage assessment, and defeat denial and deception techniques. The Low Cost Tactical Imager (LCTI) will also investigate space-based optical designs capable of performing broad area surveillance and moving target indication through such methods as foveated imaging. LCTI will demonstrate novel technologies to reduce the spacecraft mass by half and the telescope by a factor of ten to enable launch on an air launched booster such as Pegasus or RASCAL. Today's imaging spacecraft require years of lead time to manufacture the primary optic; LCTI will reduce the build time to a month using just-in-time manufacturing to enable short notice call up and eliminate the need for spare spacecraft. Key enabling technologies include lightweight optics such as Fresnel lenses, nanolaminates, membranes, deployables, inflated substrates, composite bus structures and electric propulsion.

(U) Program Plans:
– Develop candidate designs for low-cost, light-weight imaging system; estimate performance for candidate designs.
– Develop component technologies, including very light weight optics that are easy to deploy.
– Evaluate feasibility of optical moving target identification for wide area surveillance.
– Perform ground-based risk reduction experiments.
– Design, build and integrate space-based prototype.

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	FY 2002	FY 2003	FY 2004	FY 2005
HyperSoar	0.000	7.500	17.500	25.000

(U) The HyperSoar program objectives are to develop and demonstrate technologies that will enable both near-term and far-term capability to execute time-critical, global reach missions. Near-term capability will be accomplished via development of a rocket boosted, expendable munitions delivery system that delivers its payload to the target by executing unpowered boost-glide maneuvers at hypersonic speed. This concept called the Common Aero Vehicle (CAV) would be capable of delivering up to 1,000 pounds of munitions to a target 3,000 nautical miles down-range. An Operational Responsive Spacelift (ORS) booster vehicle will place CAV at the required altitude and velocity. The HyperSoar program will develop a low cost rocket booster to meet these requirements and demonstrate this capability in a series of flight tests culminating with the launch of an operable CAV-like payload. Far-term capability is envisioned to entail a reusable, hypersonic aircraft capable of delivering 12,000 pounds of payload to a target 9,000 nautical miles from CONUS in less than two hours. Many of the technologies required by CAV are also applicable to this vision vehicle concept such as high lift-to-drag technologies, high temperature materials, thermal protection systems, and periodic guidance, navigation, and control. Initiated under the Space Vehicle Technologies program, and leveraging technology developed under the Hypersonics program, HyperSoar will build on these technologies to address the implications of powered hypersonic flight and reusability required to enable this far-term capability. The HyperSoar program addresses many high priority mission areas and applications such as global presence, space control, and space lift.

(U) Program Plans:
- Complete Common Aero Vehicle (CAV) and Operational Responsive Spacelift (ORS) system designs.
- Perform periodic trajectory analysis for vision vehicle.
- Complete vision vehicle system level design.
- Initiate preliminary design of CAV and ORS vehicles.
- Perform technology validation for reusable, hypersonic aircraft.
- Conduct critical design review of CAV and ORS and initiate fabrication.
- Initiate preliminary design of the reusable technology demonstration vehicle.
- Conduct CAV flight experiments using existing boosters.
- Conduct ORS flight experiments.
- Conduct ORS flight test with CAV prototype separation.

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- Conduct critical design review of X-vehicle and initiate fabrication.
- Conduct flight testing of advanced reusable technologies.

	FY 2002	FY 2003	FY 2004	FY 2005
Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST)	0.000	0.000	5.000	9.000

(U) The Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST) program will provide a space-based capability to detect and track on-orbit objects with rapid revisit rates and low latencies. The system will feature a moderate-sensitivity, wide-field-of-view optical telescope hosted in a low-cost, rapid deployment microsatellite constellation. Space-based deployment facilitates event detection with extremely low latency, and low-cost deployment allows sufficient assets to provide global coverage. Key technologies include light-weight mirror technology to provide moderate apertures within extremely constrained spacecraft weight constraints and dynamic frame read-out charge coupled device sensors to allow adaptive tasking.

(U) Program Plans:

- Demonstrate light-weight optics fabrication capability.
- Complete telescope design.
- Complete charged coupled device design lay-out.
- Complete system design.

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	FY 2002	FY 2003	FY 2004	FY 2005
High Frequency Active Auroral Research Project (HAARP)	0.000	10.200	15.000	15.000

(U) The High Frequency Active Auroral Research Project (HAARP) will develop new experimental research capabilities and will conduct research programs to exploit emerging ionosphere and radio science technologies related to advanced defense applications. The FY 1990 Appropriation Act provided funds for the creation of HAARP, jointly managed by the Air Force Research Laboratory and the Office of Naval Research to exploit emerging ionosphere and high power radio technology for new military systems applications. Key to this effort is the expansion of an experimental research facility that includes a 3.6 MW high-frequency transmitter and a variety of diagnostic instruments, to conduct investigations to characterize the physical processes that can be initiated and controlled in the ionosphere and space, via interactions with high power radio waves. Among these are: (1) the generation of extremely low frequency/very low frequency radio waves for submarine and other subsurface communication, the imaging of underground features and deeply buried targets, and the reduction of charged particle populations in the radiation belts (through direct coupling or with augmenting electro-dynamic (ED) tethers) to ensure safe spacecraft systems operations; (2) the control of electron density gradients and the refractive properties in selected regions of the ionosphere to create radio wave propagation channels; and (3) the generation of optical and infrared emissions in space to calibrate space sensors. To date, the facility has been developed to include a suite of optical and radio diagnostics and an advanced, modern, high frequency transmitting array that has a radiated power of 960 kW, about one-third of the 3.6MW called for in the original concept and plan. The current facility has proven to be extremely reliable and flexible, and has shown the feasibility of the overall concept. Basic and exploratory development research programs are now being conducted routinely with it. Results to date indicate that advanced applications-related research activities and new military system concept demonstrations envisioned under the program require that the high frequency transmitting capability at the site be increased from the present 960 kW level to the originally planned 3.6 MW level. A recent study completed by an Air Force/Navy Panel also points to additional high-value functions that can potentially be accomplished with the a 3.6 MW capability, in particular, the exploration and refinement of scientific principles that could lead to the development and deployment of a system to provide protection for space-based assets from emergent asymmetric threats.

(U) Program Plans:

- Complete the HAARP physical facility at the HAARP Research Station, Gakona, AK.
- Operate and maintain the physical facility.
- Conduct advanced ionosphere and radio science research and analysis of applications including space-based asset protection and phenomena related to its implementation.

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	FY 2002	FY 2003	FY 2004	FY 2005
Suborbital Space Launch Operations	0.000	2.439	0.000	0.000

(U) The goal of the Suborbital Space Launch Operations program is to develop and demonstrate a piloted, reusable suborbital launch vehicle initially to perform short duration testing of space flight hardware, and ultimately to provide a platform for tactical battlefield surveillance.

(U) Program Plans:

- Design fabricate and test restartable modular propulsion system capable of providing both ascent and descent propulsion.
- Demonstrate propulsion system operation including restart without maintenance or refueling.

	FY 2002	FY 2003	FY 2004	FY 2005
Space Assembly and Manufacture	0.000	0.000	7.733	13.000

(U) The goal of the Space Assembly and Manufacture program is to examine and validate technical options for manufacturing large space structures outside the confines of the Earth's gravity. Manufacturing in the space environment will enable novel structures that could not survive the loads experienced during terrestrial launch. Extremely large structures enable resolution and accuracy from optical and radar systems that are not otherwise conceivable. Such structures are important to antennas, optics, solar collectors and other technologies to address both National security and energy issues. The Space Assembly and Manufacture program will comprise resource utilization, robotic processing, enabling structures, micro-satellite sensors, propellants and power generation. Manufacturing processes, such as vacuum deposition, that can take advantage of the space environment will be included. Mass and complexity minimization of key components will drive the design of the system.

(U) Program Plans:

- Identify key technical challenges and define a demonstration mission to resolve critical issues for space manufacture.
- Develop microsatellite sensor platforms that can determine chemical composition and location of resources on non-terrestrial objects.
- Design, fabricate and test miniaturized robotics capable of remotely processing materials and building rudimentary structures.
- Perform utility assessments of space manufacture in conjunction with operational customers and plan for technology transition.

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

Orbital Express Space Operations Architecture	FY 2002	FY 2003	FY 2004	FY 2005
NASA	8.000	9.000	8.000	0.000

High Frequency Active Auroral Research Project (HAARP)	FY 2002	FY 2003	FY 2004	FY 2005
PE 0601153N, Navy	0.000	12.500	15.000	16.000
PE 0602601F, Air Force	0.000	0.000	10.000	10.000

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COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	192.895	158.987	174.150	172.151	161.258	170.313	172.293	201.381
Uncooled Integrated Sensors MT-03	5.605	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Electronic Module Technology MT-04	31.403	21.487	17.028	17.972	18.102	26.872	30.749	30.719
Centers of Excellence MT-07	5.000	4.783	4.000	0.000	0.000	0.000	0.000	0.000
Advanced Lithography MT-10	33.321	34.053	24.606	24.520	0.000	0.000	0.000	0.000
MEMS and Integrated Micro-systems Technology MT-12	40.716	25.736	26.204	27.462	30.599	9.771	0.000	0.000
Mixed Technology Integration MT-15	76.850	72.928	102.312	102.197	112.557	133.670	141.544	170.662

(U) Mission Description:

(U) The Advanced Electronics Technology program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and process technologies for the production of various electronics and microelectronic devices, sensor systems, actuators and gear drives that have military applications and potential commercial utility. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements.

(U) The Uncooled Integrated Sensors project addressed a long-standing Defense requirement for uncooled infrared sensor arrays for major weapons systems that cannot accommodate costly cryogenic cooling packages. This program completed in FY 2002.

(U) The Electronic Module Technology project is a broad initiative to decrease the cost and increase the performance of weapon systems through the insertion of electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. Included in this project is the

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Semiconductor Ultraviolet Optical Sources (SUVOS), the Photonic Analog/Digital A/D Conversion, Distributed Robotics and the Direct Energy Conversion initiatives.

(U) Advanced Lithography technology has enabled the dramatic growth of integrated circuit capability. Advances have led to improvements in electronic and computing systems performance in terms of speed, power, weight and reliability. Further improvements require microcircuits with smaller features to meet the operational speed, power, weight and volume constraints.

(U) The Microelectromechanical Systems (MEMS) and Integrated Microsystems Technology project is a broad and cross-disciplinary initiative to develop an enabling technology that merges computation and power generation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, opto-electronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards and physiological states.

(U) The goal of the Mixed Technology Integration project is to revolutionize the integration of mixed technologies at the micrometer/nanometer scale. This will produce low-cost, lightweight, low-power 3-D microsystems that improve battlefield awareness and the operational performance of military platforms. This project will leverage industrial manufacturing infrastructure to produce mixed-technology microsystems that will revolutionize the way warfighters see, hear, taste, smell, touch and control environments.

(U) The Centers of Excellence project finances demonstration, training and deployment of advanced manufacturing technology at Marshall University and the Defense Techlink Rural Technology program. This effort will complete during FY 2004.

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(U) **Program Change Summary:** *(In Millions)*	**FY 2002**	**FY 2003**	**FY 2004**	**FY2005**
Previous President's Budget	199.564	150.400	148.070	143.776
Current President's Budget	192.895	158.987	174.150	172.151
Total Adjustments	-6.669	8.587	26.080	28.375
Congressional program reductions	0.000	-8.013		
Congressional increases	0.000	16.600		
Reprogrammings	+3.331	0.000		
SBIR/STTR transfer	-10.000	0.000		

(U) **Change Summary Explanation:**

FY 2002	Decrease reflects SBIR transfer and below threshold reprogrammings.
FY 2003	Increase reflects Congressional adds for advanced lithography programs, novel crystal growth, and MEMS, offset by Congressional program and undistributed reductions.
FY 2004 – 2005	Increases reflect new initiatives in project MT-12 that apply cryogenic cooling to MEMS-based components and utilize MEMS sensors to detect airborne particles. In addition, a number of ongoing programs in project MT-15 have been expanded, particularly in the area of componentry for optical networks and chip-scale wave division multiplexing.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Electronic Module Technology MT-04	31.403	21.487	17.028	17.972	18.102	26.872	30.749	30.719

(U) Mission Description:

(U) The Electronic Module Technology Project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards, and emerging technologies such as high density Multichip Modules. The project has three major objectives: (l) shorten the overall design, manufacture, test and insertion cycle for advanced electronic subsystems; (2) advance the state-of-the-art in electronic interconnection and physical packaging technology to allow circuits to operate close to their intrinsic maximum speed with less overhead in terms of volume, weight and cost; and (3) provide a robust manufacturing infrastructure for electronic modules.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Semiconductor Ultraviolet Optical Sources (SUVOS)	11.620	18.303	15.551	10.004

(U) The Semiconductor Ultraviolet Optical Sources (SUVOS) program will develop photonic wide band gap materials for optical emission in the ultraviolet for bio sensing, and covert communications applications. This program will develop high conductivity *p*-type (positive charge carrier) material and highly efficiently active region material suitable for ultraviolet emission, and exploit these results to enable the development of heterojunction bipolar transistors (HBT). The program will demonstrate short-wavelength semiconductor ultraviolet optical sources operating at wavelengths as short as 280 nm. Compared to conventional technologies, this program will achieve: 50x reduction of power requirements, 100x reduction of size and weight. This program will enable microsystems for biological agent detection, and covert non-line-of-sight (NLOS) tactical communications.

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(U) Program Plans:

- Demonstrate *p*-type (positive charge carrier) doping in high aluminum concentration nitride materials at concentrations sufficient for minority carrier injection devices.
- Demonstrate minority carrier devices (e.g. light emitting diodes (LED), laser diodes, heterojunction bipolar transistors).
- Develop and demonstrate 340 nm laser diodes and LEDs.
- Develop and demonstrate <280 nm laser diodes and LEDs.
- Demonstrate prototype microsystems based on SUVOS devices.

	FY 2002	FY 2003	FY 2004	FY 2005
Photonic A/D	11.733	2.000	0.000	0.000

(U) The Photonic Analog/Digital (A/D) conversion program will utilize breakthrough photonic developments that substantially increase the speed that analog signals are converted into digital data streams for data reduction and processing.

(U) Program Plans:

- Completed photonic analog/digital converter technology development.
- Integrated photonic clock and sampler modules with electronic quantizers.
- Demonstrated high linearity and dynamic range.

	FY 2002	FY 2003	FY 2004	FY 2005
Distributed Robotics	8.050	0.000	0.000	0.000

(U) The Distributed Robotics program integrated developments in Microelectromechanical Systems (MEMS), power sources, communications and advanced microelectronics to design, construct and field multiple, high-performance, mobile, autonomous systems. Design tools were developed (concept exploration, analysis, optimization and verification) to allow thousands of analog, digital, optical, MEMS and microfluidic devices to be integrated into “systems-on-a-chip” and other highly integrated mixed technology systems.

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(U) Program Plans:
- Completed current contracts on micro robot developments.
- Delivered prototype hardware and final reports.
- Demonstrated prototype robotic systems to operational military users.

	FY 2002	FY 2003	FY 2004	FY 2005
Very High Speed Digital and Mixed Signal Microsystems	0.000	1.184	1.477	7.968

(U) This initiative addresses development of the key technologies that will accelerate the availability of extremely high performance circuits that meet emerging DoD needs while also leveraging the pull from commercial applications. This program, in two thrusts, is developing robust methods for attaining extreme precision and performance in mixed signal/analog signal processing with low power dissipation. This program is developing technologies for integrating multiple compound semiconductors with silicon and silicon-based alloy materials, and new wafer-scale approaches with deeply embedded circuit implementations that exploit large device counts to implement sophisticated chip-scale circuits for new DoD applications.

(U) Program Plans:
- Demonstrate bonding and interconnection of two different semiconductor circuit technologies.
- Make dynamic measurements of performance and power dissipation.
- Demonstrate digital correction circuits for non-linear compensation of analog signals.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Centers of Excellence MT-07	5.000	4.783	4.000	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University. The Byrd Institute provides both a teaching factory and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training includes technologies to significantly reduce unit production and life cycle costs and to improve product quality. This project also includes funding for the Defense Techlink Rural Technology Transfer Project.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Flexible Manufacturing	4.000	3.808	4.000	0.000

(U) Program Plan:
- Continue the assessment of the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support.

	FY 2002	FY 2003	FY 2004	FY 2005
Defense Techlink Rural Technology Transfer Project	1.000	0.975	0.000	0.000

(U) Program Plan:
- Provide funding for the Defense Techlink Rural Technology Transfer Project.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10			
COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Lithography MT-10	33.321	34.053	24.606	24.520	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) Microelectronics is a key to improved weapon system performance. Lithography technology has enabled the dramatic growth in microelectronics capability over the past three decades. The improved capabilities in semiconductor technology have contributed to significant system gains in speed, reliability, cost, power consumption and weight. Advanced microelectronics technology has been essential for computing and signal processing in virtually all military systems including command, control, communications and intelligence; electronic warfare; and beam forming for radar and sonar. Further improvements in areas such as target recognition, autonomous guided missiles and digital battlefield applications require microcircuits with smaller features to meet the operational speed, power, weight and volume constraints of these systems. Current microelectronics fabrication utilizes feature sizes of 0.18 microns. The Advanced Lithography program has emphasized longer-term research with expected high payoff in the fabrication of semiconductor devices with 0.05 or less micron feature sizes. These efforts will develop technology for sub 0.05 micron features.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Lithography	21.221	23.517	24.606	24.520

(U) The goal of the Advanced Lithography program is to reduce technical barriers to the development of advanced lithographic technologies for the fabrication of a broad range of microelectronic devices and structures. Innovative research in pattern generation and transfer, imaging materials, new process and metrology will provide alternatives beyond current evolutionary trends. Maskless approaches will address the low volume needs of military systems. The program will investigate technologies for the creation of highly complex patterns at sub 0.05 μm resolution over field areas in excess of 1000 mm^2. Applications with larger geometries will be explored for innovative devices and structures beyond microelectronics, including photonics and bio-arrays.

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(U) Program Plans:
- Develop thinner resists appropriate for emerging exposure sources.
- Develop mask technology (writing, inspection and repair), resists and metrology for lithography for 0.05 micron and below.
- Exploit advances from longer term developments in direct write-on-wafer projects.
- Develop sub systems for maskless and imprint lithography systems.
- Develop maskless lithography tool for sub 50 nm.
- Develop data handling (terabits/sec) for maskless lithography.
- Develop support technologies (masks, resist, and inspection) for projection lithography.
- Develop support technology (template, inspection, and repair) for imprint lithography.

	FY 2002	FY 2003	FY 2004	FY 2005
Laser Plasma X-Ray Source	4.300	2.536	0.000	0.000

(U) Program Plans:
- Continue laser plasma x-ray source technology.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Lithography Demonstration	4.300	3.903	0.000	0.000

(U) Program Plans:
- Continue point source lithography development.

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	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Lithography X-Ray Thin Film Development	3.500	4.097	0.000	0.000

(U) Program Plans:

– Continue X-Ray mask lithography thin film development.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA3 Advanced Technology Development	Advanced Electronics Technology PE 0603739E, Project MT-12

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
MEMS and Integrated Micro-systems Technology MT-12	40.716	25.736	26.204	27.462	30.599	9.771	0.000	0.000

(U) Mission Description:

(U) The Microelectromechanical Systems (MEMS) program is a broad, cross-disciplinary initiative to develop an enabling technology that merges computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS provides the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale power and actuation systems as well as microscale components that survive harsh environments. The microfluidic molecular systems program will develop automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules to perform tailored analysis sequences to monitor environmental conditions, health hazards and physiological states.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
MEMS Micro Power Generation	17.883	6.164	6.142	0.000

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) mass data storage;

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5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

(U) Compact portable power sources capable of generating power in the range of a few hundred milliwatts to one watt are critical to providing power for untethered sensors and other chip-scale microsystems. This program aims to replace today's technologies relying on primary and rechargeable batteries, which severely limit mission endurance and capabilities, by extending microelectronic machine technology to develop micro-power generators based on mechanical actuation and thermal-electric power generation. Operating with traditional fuels, these micropower generators will be capable of generating sustained power in the desired range for use with remote, field-deployed microsensors and microactuators.

(U) Finally, the program will explore innovative micro-scale, integratable power sources to provide high density energy sources.

(U) Program Plans:

- Demonstrate capabilities in fuel processing, energy conversion to electricity, thermal and exhaust management.
- Demonstrate MEMS micro heat engines utilizing micropower sources.
- Demonstrate integration of various power-generation components with microsensors and microactuators.
- Demonstrate stand alone, remotely distributed microsensors and actuators with built-in power supply and wireless communication.
- Establish design paradigm-shifts that occur when implementing novel power sources at the micro-scale using MEMS technology.

	FY 2002	FY 2003	FY 2004	FY 2005
Bio-Fluidic Chips (BioFlips)	14.114	12.858	0.000	0.000

(U) The Bio-Fluidic Chips program is funding development of totally integrated microfluidic chips to enable ubiquitous yet unobtrusive assessment of the warfighter's body fluids. These microchips integrate detection, diagnostics and treatment in one chip-scale system.

(U) Program Plans:

- Demonstrate optimization of sub-systems and components for integration into prototype systems. Sub-systems include: 1) on-chip sample preparation and processing (on-chip flow/concentration regulators, biosignal amplification, on-chip pressure sources, on chip

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separation/mixing, reagents storage/reconstitution); 2) sample collection (body fluid extractors, concentrators); and 3) antidote synthesis (genetic and antibodies) subsystems.

- Identify partners in the DoD and other federal agencies for testing prototype systems.
- Perform preliminary testing of prototype systems for re-evaluation of sub-system functionality.
- Modify sub-systems based on preliminary testing of prototype systems.
- Finalize testing of prototype systems to optimize integrated performance.
- Demonstrate prototype BioFlip systems in field insertions.

	FY 2002	FY 2003	FY 2004	FY 2005
Harsh Environment Micromechanical Devices (Chip Scale MEMS Micro-Cooler)	0.000	3.730	5.000	10.000

(U) The Harsh Environment Micromechanical Devices (HEMD) Program aims to demonstrate micromechanical devices that can operate under harsh conditions—e.g., under large temperature excursions, large power throughputs, high g-forces, corrosive substances, etc.—while maintaining unprecedented performance, stability, and lifetime. Although HEMD realizations of micromechanical RF switches are of particular interest, where sizable power throughputs and impacting operation constitute harsh operational environments, implementations for vibrating resonator reference tanks, gyroscopes, and accelerometers are also of interest. Among the HEMD implementation approaches deemed likely to succeed are two of most interest: (1) wafer-level encapsulation or packaging strategies based on MEMS technology that isolate a micromechanical device from its surroundings while maintaining a desired environment via passive or active control; or (2) material and design engineering strategies that render a micromechanical device impervious to its environment, with or without a package (if possible). A key approach in this program that should allow orders of magnitude power savings is to selectively control only the needed micro-scale environment or volume via MEMS-enabled isolation technologies. The success of this program should enable a myriad of strategic capabilities, including lower cost, more complex phased array antennas for radar applications; tiny frequency references with long- and short-term stabilities that greatly extend the portability of ultra-secure communications; and micro-scale inertial measurement units with bias stabilities approaching navigation-grade.

(U) Program Plans:

- Establish the feasibility of encapsulating micromechanical devices under low-cost, wafer-level packages with minimal out-gassing or leaking and with minimal impact on device performance.

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- Demonstrate engineered materials and/or surface treatments that render a micromechanical device impervious to its surroundings or operating environment.
- Demonstrate essential elements (e.g., thermistors, heaters, getters, etc.) needed for low power control of the operating environment surrounding a micromechanical device.
- Demonstrate micromechanical devices (e.g., RF switches, vibrating resonators, etc.) fully integrated together with environment isolating measures (including circuits, if any) that maintain unprecedented performance, stability, and reliability, even under harsh environments.

	FY 2002	FY 2003	FY 2004	FY 2005
Chip-Scale Gas Analyzers (MEMS Based Airborne Particle Detection)	0.000	0.000	5.000	10.000

(U) The Chip-Scale Gas Analyzer Program intends to utilize the latest MEMS technologies to implement separation-based analyzers (e.g., gas chromatographs, mass spectrometers, poly-chromator-like devices) at the micro-scale to greatly enhance the selectivity of sensors to specific species, and thus, enable extremely reliable, remote detection of chemical/biological agents. The use of MEMS technology should also increase analysis speed and make possible the operation of such complex analyzer systems at extremely low power levels—perhaps low enough for operation as autonomous, wireless sensors. The many challenges in this program include the exploration and realization of micro-scale preconcentrator approaches, stacked gas columns, multiple sensor arrays, ionizers, vacuum pumps, and vacuum packaging. The success of this program will yield sensors substantially more selective than conventional sensors, again, making them particularly suitable for detection and identification of airborne toxins.

(U) Program Plans:

- Establish design trade-offs in (column) length vs. species separation efficiency for micro-scale gas chromatographs, mass spectrometers, resonator-based separation mechanisms, etc.
- Demonstrate MEMS-enabled, micro-scale preconcentrators and explore the degree to which they enhance separation efficiency and species detectability.
- Demonstrate MEMS-enabled, micro-scale separation columns, ionizers, electromagnetic field generators, vacuum pumps, gas sensor arrays, calibration sources, all needed for separation-based analyzers.

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- Demonstrate advanced methods for making micromechanical sensor elements species sensitive (e.g., combinations of absorption spectroscopy and resonators coated with species-and-light sensitive films).
- Implement fully functional, MEMS-enabled gas separation analyzers with power consumptions small enough for autonomous, remote operation and with control electronics integrated directly.

	FY 2002	FY 2003	FY 2004	FY 2005
MEMS Exchange	0.000	0.000	3.868	5.305

(U) This program seeks to provide flexible access to complex Microelectromechanical Systems (MEMS) fabrication technology in a wide variety of materials and to a broad multi-disciplinary user base via the MEMS Exchange service. A major goal of the effort is to ensure self-sustained operation of MEMS Exchange after the end of the program by adding several process modules to the existing repertoire and increasing the number of processes run per year so as to raise revenues to the point of self-sufficiency. Among the future payoffs of this program is the establishment of an accessible infrastructure for low or medium volume production of MEMS-enabled products for DoD applications.

(U) Program Plans:

- Demonstrate online software capable of error checking and optimizing process flows input by users so as to reduce the turn-around time per run and increase success rate.
- Insert a MEMS process module into the MEMS Exchange repertoire and make it available for use.
- Double the number of runs processed per year, achieving 300 runs per year.
- Provide a modular merging process that combines modules together with transistor integrated circuits.
- Insert MEMS technology into three DoD applications using MEMS Exchange as the fabrication vehicle.
- Achieve a process run rate of 500 runs per year.

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	FY 2002	FY 2003	FY 2004	FY 2005
RF MEMS	3.519	0.000	0.000	0.000

(U) RF MEMS switches in the X, Ka, and Ku band hold great promise for DoD radar applications due to their inherent small size, light weight, low power consumption and low loss. The RF MEMS Improvement program will extend lifetimes, develop inexpensive packaging techniques, and enhance RF performance of RF MEMS switches to allow use in devices such as phase shifters, reconfigurable apertures, and tunable filters. RF MEMS is funded in PE 0603762E, Project SGT-03 in FY 2003 and out.

(U) Program Plans:
- Develop mechanical and electrical models to reduce design iteration time and enable performance increases.
- Fabricate and analyze test structures to fully understand and predict failure mechanisms for RF MEMS.
- Conduct fabrication of benchmark devices.
- Establish micro-scale mechanical techniques for neutron absorption and control by introducing new materials to the suite of micromachinable ones (e.g., boron).
- Use MEMS technology to demonstrate micro-scale initiators, neutron absorbers, and fuel separation chambers.

	FY 2002	FY 2003	FY 2004	FY 2005
MEMS Mechanical Computation and Data Storage	0.000	0.000	6.194	2.157

(U) The Micromechanical Computation and Data Storage Program aims to harness the low loss and low thermodynamic noise floor inherent in mechanical structures to (1) attain computational and signal processing circuits with unprecedented robustness and record low power consumption; and (2) to realize archival data storage devices with better than 1000Gb/in^2 densities. The key to attaining such performance is the recognition that mechanical structures are circuit elements in their own right, each with the capability to filter signals via their resonance properties, switch signals via mechanical actuation, and distort/shape/amplify signals via their nonlinearities, all at bandwidths rivaling those of transistors when implemented on the nano-mechanical scale. When connected into larger circuit networks, such mechanical elements can then be structured to perform increasingly complex functions, including filtering, mixing, amplification, and A/D or D/A conversion, all with dynamic ranges and

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power usages potentially better than exhibited by transistor-based counterparts. For data storage, the key approach in this program that allows it to break the 100Gb/in^2 thermodynamic barrier presently constraining conventional magnetic storage approaches is the use of MEMS technology to store, access, and erase data as tiny pits, phase changes, or even molecular changes (e.g., in a DNA chain). One possible rendition might use a MEMS based probe to manipulate the bits. A successful program in micromechanical computation and data storage would not only make single-chip (electrical or mechanical) computers possible, but would also enable circuits that can be powered by means other than electrical energy (e.g. direct chemical energy is possible), and that are practically immune to Electro-Magnetic Interface (EMI) and robust against radiation.

(U) Program Plans:

- Demonstrate mechanical circuit elements capable of manipulating a set of signal types (e.g., mechanical, electrical, acoustic) in various domains (e.g., frequency, time).
- Establish the feasibility of writing, reading, and erasing data using alternative storage mechanisms with higher thermodynamic density limits (> 1000Gb/in^2); (e.g., structural change-based (pits), phase change-based, DNA-chain-change based).
- Demonstrate methods for improving the data rate of data storage devices based upon the above techniques (e.g., by using MEMS-enabled massively parallel construction) while maintaining high read/write reliability.
- Design and demonstrate mechanical circuit networks capable of performing needed computational or signal processing functions (e.g., addition, multiplication, mixing, amplification, A/D conversion) with extremely low power consumption, and with immunity to EMI or radiation interference.

	FY 2002	FY 2003	FY 2004	FY 2005
MEMS Micro-Actuator Technology	0.000	1.423	0.000	0.000

(U) Program Plans:

- Initiate novel design concepts of MEMS Micro-Actuators.

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	FY 2002	FY 2003	FY 2004	FY 2005
MEMS Deep Silicon Etching Technology	5.200	1.561	0.000	0.000

(U) Program Plans:

– Continue MEMS Deep Etching program in conjunction with Army Research Laboratory.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Mixed Technology Integration MT-15	76.850	72.928	102.312	102.197	112.557	133.670	141.544	170.662

(U) Mission Description:

(U) The goal of the Mixed-Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems that will revolutionize the way individuals see, hear, taste, smell, touch and control their environment at a distance. These 'wristwatch size', low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: Microelectromechanical Systems (MEMS), microphotonics, microfluidics and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration of mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'.

(U) The field of microelectronics incorporates micrometer/nanometer scale integration and is the most highly integrated, low-cost and high-impact technology to date. Microelectronics technology has produced the microcomputer-chip that enabled or supported the revolutions in computers, networking and communication. This program extends the microelectronics paradigm to include the integration of heterogeneous or mixed technologies. This new paradigm will create a new class of 'matchbook-size', highly integrated device and microsystem architectures. Examples of component-microsystems include low-power, small-volume, lightweight, microsensors, microrobots and microcommunication systems that will improve and expand the performance of the warfighter, military platforms, munitions and UAVs.

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using 'standard' processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and 'multiple-chip-scale' packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave technologies. For example, a mixed-technology microsystem using integrated microfluidics, MEMS, microphotonics, microelectronics and microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment. The ability to integrate mixed

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technologies onto a single substrate will drive down the size, weight, volume and cost of weapon systems while increasing their performance and reliability.

(U) <u>Program Accomplishments/Planned Programs:</u>

	FY 2002	FY 2003	FY 2004	FY 2005
Steered Agile Laser Beams (STAB)	12.517	12.347	0.000	0.000

(U) The Steered Agile Laser Beams (STAB) program is developing small, lightweight laser beam scanning technologies for the replacement of large, heavy gimbaled mirror systems. New solid state/micro-component technologies such as optical MEMs, patterned liquid crystals and diffractive micro-optics will be used to build small, ultra-light, rapidly steered laser beam sub-systems.

(U) Program Plans:

- Analyze system concepts that will be used to develop design goals for assembled components.
- Fabricate individual laser beam steering components (lasers, diffractive optics, MEMS sub-assemblies, detectors, filters and integrated circuits).
- Resolve component interface issues in preparation for breadboard development.
- Evaluate competing laser beam steering component technologies; down-select to the most promising approaches.
- Complete prototype design studies.
- Assemble and test components suitable for use in prototype demonstration and evaluation.
- Assess performance characteristics of the prototypes and make recommendations for future development.

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	FY 2002	FY 2003	FY 2004	FY 2005
RF Lightwave Integrated Circuits (RFLICS)	10.100	7.674	4.769	0.000

(U) The Radio Frequency (RF) Lightwave Integrated Circuits (RFLICS) program is demonstrating enhanced performance capabilities of RF systems enabled by integration of lightwave and RF technologies to route, control, and process analog RF signals in the 0.5 – 50 Ghz range.

(U) Program Plans:

- Determine the quantitative performance requirements of computationally intensive weapons systems tasks such as RF channnelization, local oscillator distribution, antenna beam forming, jammer nulling, and signal synthesis and frequency conversion.
- Use results of earlier RF photonics single chip development efforts to establish goals for RF photonic component fabrication.
- Integrate recently developed emitters, waveguides, detectors and integrated circuits to produce RF photonic component prototypes.
- Complete the design and fabrication of RF photonic prototypes.
- Construct testbeds capable of producing realistic systems demands for the demonstration and evaluation of RF lightwave integrated circuit components and assemblies.
- Measure and analyze the operational impact of the photonic domain for advanced RF signal transmission, conditioning and processing.

	FY 2002	FY 2003	FY 2004	FY 2005
Nano Mechanical Array Signal Processor (NMASP)	10.087	17.301	16.514	0.000

(U) The Nano Mechanical Array Signal Processors (NMASP) will create arrays of precision; nano mechanical structures for radio frequency (RF) signal processing that will greatly reduce the size and power consumption of various communication systems.

(U) Program Plans:

- Demonstrate fabrication techniques to control surface morphology, geometry, and material properties at the sub-micron scale.
- Demonstrate temperature stability and electrical tenability of individual nano resonators suitable for UHF communication.

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- Initiate development of nano mechanical array signal processors that will enable ultra miniaturized (wristwatch or hearing aid in size) and ultra low power UHF communicators/GPS receivers.
- Demonstrate several alternatives to achieve uniform arrays of up to 1024 nano resonators with geometrical control and material uniformity at $\pm$20%, and to $\pm$1% with trimming and tuning.
- Demonstrate interconnection and isolation (multiplexed, serial, or random access) of individual resonators.

	FY 2002	FY 2003	FY 2004	FY 2005
Digital Control of Analog Circuits RF Front Ends	6.827	15.517	16.732	17.712

(U) Digital Control of Analog Circuits will demonstrate analog/RF electronic components with the ability to self-assess and adapt in real time (sub microseconds), by self-tuning its impedance-matched networks, extending the operational performance of analog components to the intrinsic semiconductor device limits. This technology will result in a new generation of analog, microwave and millimeter wave components with >150X improvements in power-bandwidth, linearity-efficiency products.

(U) Program Plans:

- Demonstrate real-time active self-assessment and monitoring of RF/analog functions using nano-CMOS digital and mixed-signal technologies to achieve stability, signal agility, and multifunctionality.
- Design processes to fabricate arrays of molecular flow control devices including interconnect microfluidics and electronics.
- Develop techniques and algorithms to monitor active device status.
- Demonstrate MEMs tunable device optimization (<1 microsecond, 10:1 tuning ratio).
- Fabricate tunable MEMs control Integrated Circuits (ICS).
- Fabricate self-assessment control Integrated Circuits (ICS).
- Demonstrate device and algorithm concepts for intelligent self-assessment of analog functions.
- Demonstrate device concepts for 10^5 microsecond actuation time of impedance matched networks.
- Complete design concept for adaptable RF components.
- Demonstrate concept of digital assessment of analog device.
- Demonstrate reconfigurable network concept for 10^5 microsecond actuation time of impedance matched networks.

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- Validate concept of adaptable RF components by demonstrate digital control of analog circuits.
- Identify component requirements.
- Initiate Phase III – component demonstration.

	FY 2002	FY 2003	FY 2004	FY 2005
Chip Scale Wavelength Division Multiplexing (WDM)	9.965	18.430	18.763	14.769

(U) The goal of the Chip Scale Wavelength Division Multiplexing (WDM) program is to develop new materials, components and sub-systems for use in wavelength division multiplexing based optical communications, delivering high capacity, mission adaptable networks for use in data intensive military weapons systems.

(U) Program Plans:

- Conduct modeling, simulation and analysis of artificial dielectrics and new materials for ultra-compact Wavelength Division Multiplexing (WDM) components.
- Conduct experimental efforts in the growth and fabrication of these new materials and determine suitable processing procedures.
- Plan construction of WDM components.
- Design, fabricate and test novel WDM components using the new materials and processing technology.
- Determine fiberoptic and planar waveguide interconnection requirements.
- Evaluate the suitability of the new components for use in prototype modules.
- Down-select to the most promising approaches and begin prototype module assembly.
- Construct testbeds capable of fully measuring and characterizing the new technologies implemented in the chip-scale WDM components.
- Evaluate the performance characteristics of the prototype modules and determine the highest payoff dual use development paths.
- Evaluate and demonstrate network with device testing.
- Demonstrate network with completed modules.

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	FY 2002	FY 2003	FY 2004	FY 2005
Optical Code Division Multiple Access (CDMA)	0.000	0.000	7.677	12.767

(U) Optical CDMA represents a paradigm shift from the current WDM/TDM optical networks. Instead of assigning a wavelength and a time slot to a user, O-CDMA assigns a code to a user. The goal of this program is to demonstrate technology for an advanced O-CDMA communications system. Such a system potentially offers the benefit of multi-level security, low probability of interception, detection and jamming, decentralized network, and higher spectral efficiency.

(U) Program Plans:

- Demonstrate 10 simultaneous users at 10 Gb/s per user with a low bit error rate.
- Demonstrate scalability to 100 simultaneous users and cardinality of 1000.
- Demonstrate spectral efficiency scalable to 1 bit/s-Hz.

	FY 2002	FY 2003	FY 2004	FY 2005
Robust Sensors	0.000	0.000	4.000	6.000

(U) The operation of sensors in harsh environments requires materials with superior mechanical and chemical properties. Silicon Carbide (SiC), Gallium Nitride (GaN), and diamond, initially developed for their attractive electrical properties, also have extremely high coefficients of hardness and are largely chemically inert. Recent advances in the deposition of SiC, GaN, and diamond along with techniques to pattern these materials, have opened an opportunity to develop a new class of sensors taking advance of these materials unique properties. Of particular interest is the large piezoelectric coefficient of some of this material, notably GaN that can be exploited to produce very sensitive strain sensors. The program will make use of MEMs techniques developed in Si-technology, and other materials, to develop a new class of robust sensors based on SiC, GaN, and diamond.

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(U) Program Plans:
- Perform concept study to identify sensor concepts enabled by unique materials properties of wide bandgap semiconductors or other emerging materials.
- Identify key technical challenges and quantify impact of potential platforms.
- Identify compelling applications and opportunities for integration with electronics.
- Optimize material growth and processes for specified sensors.
- Develop micromachining techniques for wide bandgap semiconductors.
- Demonstrate low power enhancement/depletion mode wide bandgap transistors for robust analog sense and control circuits.

	FY 2002	FY 2003	FY 2004	FY 2005
Radiation Resistant Mixed Signal Electronics	0.000	0.000	5.609	8.922

(U) This program will develop, characterize, and demonstrate the mixed-signal *Rad-by Design* solution with assured access to commercial foundry for low volume applications.

(U) Program Plans:
- Determine intrinsic hardness for pre-radiation hardness.
- Test as required.
- Design standard foundry flexible process evaluation chip(s) (PEC's).
- Fabricate and test PEC(s).
- Identify failure mechanisms.
- Refine radiation hardness.

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	FY 2002	FY 2003	FY 2004	FY 2005
Intelligent Optical Networks	0.000	0.000	5.000	7.922

(U) Currently optical networks use photonics to transport data and electronics to process data. However, as the underlying bit rates of the optical networks are pushed beyond 40 giga-bits per second, there will be significant processing bottlenecks in these networks and these bottlenecks will severely limit the military's ability to rapidly transport time critical information. A potential solution to this problem is to develop photonic technology so optics can take over higher order network processing functions. This program will develop and demonstrate four key photonic technologies to meet these challenges: all-optical routing, all-optical data buffering (controllable and eventually random access,), optical logic and circuits, and all-optical (multi-wavelength) regenerators. These photonic technologies will lead to intelligent all-optical networks. The program will have two major areas of interest: The first will focus on developing new photonic technology that is essential if photonics is to play a significant role in higher order processing in optical networks. The second area will focus on developing novel architecture that will fully exploit the new photonic technology to bring new and increased functionalities to the optical networks.

(U) Program Plans:
- Develop a limited (4x4 or 8x8) optical packet switch.
- Develop means for address processing.
- Develop multi-wavelength optical regenerators.
- Develop flexible, room temperature optical buffers.
- Develop synchronization techniques for short pulses.
- Develop controllable picoseconds optical time delay.

	FY 2002	FY 2003	FY 2004	FY 2005
Large Area Multifunction Distributed Electronics	0.000	0.000	6.000	9.922

(U) This program will develop large area multifunctional actuation and sensing systems using novel combinations of active and passive electronics and flexible, conformable, non-traditional materials and techniques. It will develop basic technologies and techniques for component

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attachment, electrical interconnections, multilayer routing and utilize existing novel materials and designs for actuation and sensing such as electroactive polymers to achieve active porosity and fibers for acoustic response. This program will demonstrate prototype systems that achieve order of magnitude improvements in performance and/or cost. Examples of applications include: control surfaces for an autonomous precision guided parafoil and controlled air boundary layers for reduction in drag for underwater vehicles; beam steered acoustic arrays with large aperatures to achieve order of magnitude improvements in angle of coverage and signal to noise ratios; early warning threat detection and localization using a large area inflatable structure with woven antennas and electronics for high bandwidth communications; and aircraft or UAV wing skins for chem/bio monitoring.

(U) Program Plans:

- Develop enhanced transistors compatible with low cost, large area fabrication.
- Develop methods to print active circuits on large area and flexible circuits.
- Develop techniques to wirelessly communicate between circuit blocks over a distributed electronics surface.
- Develop novel circuit/microarchitectures to enhance system performance for demanding electronic applications.
- Demonstrate examples of large area and/or flexible substrate distributed electronics to address difficult problems in sensor networks, physical security systems, or radar beam forming/steering.

	FY 2002	FY 2003	FY 2004	FY 2005
Submillimeter Wave Imaging Technology	0.000	0.000	5.000	8.923

(U) The goal of the Submillimeter Wave Imaging Technology program is to develop new radiation sources and receiver arrays that can be used in the millimeter wave/IR region for concealed weapon detection and for seeing through fog and smoke on the battlefield. Receiver arrays to be developed will include antenna structures as well as other approaches to directly measure the EM field to be sensed.

(U) Program Plans:

- Fabricate microantennas with both metal-insulator-metal structures and bolometers for sensing antenna current.
- Develop InP and other sources for pulsed incoherent millimeter wave illumination.

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- Achieve a specific detectivity of 10 exp +7 for metal-insulator-metal current sensing elements and a three-fold improvement in antenna coupling efficiency.
- Achieve five-watt pulses at 100ppsec at 94 GHz from an InP source.
- Produce 10-100 receiver array devices.
- Achieve an array sensitivity of one half degree Kelvin, more than sufficient for concealed weapon detection.
- Demonstrate seeing through a fog that has an optical density of 25.
- Achieve production yields of 30%.

	FY 2002	FY 2003	FY 2004	FY 2005
Ultra Wide Band Array Antenna	0.000	0.000	9.248	10.260

(U) The Ultra Wide Band Array Antenna effort will develop array antenna and beamforming technology to support steering from ten to one hundred independent beams with instantaneous bandwidths in excess of 100:1 from an array antenna. Frequency ranges of interest are: 20 MHz to 3 GHz, 100 MHz to 20 GHz and 500 MHz to 50 GHz.

(U) Program Plans:

- Initiate component design and simulation - radiating element, low noise amplifier, beamformer.
- Extend initial designs to support 100:1 instantaneous bandwidth.
- Validate performance by simulation, begin component fab.
- Complete component fabrication, verify component performance, and demonstrate beamformer approach for 10 elements.
- Complete prototype integration and test - prove multi-octave, multi-beam performance.

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	FY 2002	FY 2003	FY 2004	FY 2005
Flexible Nanocomposite Organic Photovoltaic Cells	0.000	0.000	3.000	5.000

(U) The goal of the Flexible Nanocomposite Organic Photovoltaic (PV) Cells is to efficiently convert solar energy to electricity utilizing nanocomposite materials on flexible, lightweight substrates. Operational impact would be 200x increase in power/weight, longer operating time before resupply, increased sustainability, and greater mobility.

(U) Program Plans:

- Deliver 2 cm2 PV cell with increased efficiency from < 3% to 20%.
- Use plastic or fabric substrates in transparent electrode and heterojunction stability.

	FY 2002	FY 2003	FY 2004	FY 2005
Multi-Function Imaging Microsystems	4.996	0.000	0.000	0.000

(U) The objective of the Multi-function Imaging Micro-systems program was to develop and demonstrate a new class of uncooled low power, light weight sensors, with an integral intelligent imaging capability, including target discrimination, multi-spectral band imaging, sensor radiation shielding and on-chip signal processing.

(U) Program Plans:

- Demonstrated 320 x 240 photon detector array integrated with a microbolometer array.
- Demonstrated 320 x 240 imaging with solid state radiation shield temperature reduction of 20 K.
- Demonstrated mid wave room temperature array 320 x 240 with sensitivity suitable for imaging.
- Demonstrated mid and long wave detection in uncooled array test structures, pixel size of 35 microns, and sensitivity 30 mk (Long-WaveIR) and 60 mk (Mid-WaveIR).

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	FY 2002	FY 2003	FY 2004	FY 2005
Anti-Tamper (AT)	7.260	0.000	0.000	0.000

(U) The goal of the Anti-Tamper (AT) initiative is to protect selected critical technologies in U.S. weapons systems that may be developed with or sold to foreign governments or that could possibly fall into enemy hands. Specifically, AT is intended to prevent technology transfer, alteration of system capability, and development of countermeasures due to weapon system co-development, sales, or potential loss on the battlefield. An AT technology base will develop complimentary AT techniques with broad applicability across the range of DoD critical technologies. Areas of AT technology interest include software, digital electronics, materials, and systems operating across the electromagnetic spectrum. The Air force, as executive agent for Anti-Tamper, assumed funding responsibility in FY 2003 and subsequent years.

(U) Program Plans:

- Facilitated information exchanges throughout the Services, DoD Agencies and Labs and industry to preclude development of duplicative technologies.
- Developed an interactive AT databank and library.
- Developed a technology roadmap required to prioritize the overall technological research and development effort.
- Developed AT technology throughout the Radio/Frequency/Gallium Arsenide and Digital Gallium Arsenide domains.

	FY 2002	FY 2003	FY 2004	FY 2005
3-D Imaging Devices	9.098	0.000	0.000	0.000

(U) The 3-Dimensional Imaging Devices program developed new high speed imaging devices and array technology which rapidly acquired high resolution (less than 6 inches in range) three dimensional images of tactical targets at ranges of 7 to 10 kilometers, which increased identification range of tactical targets, especially from fast moving platforms.

(U) Program Plans:

- Demonstrated range imaging at the eye-safe wavelength of 1.54 micrometers, with a minimum array size of 64x64. The goal is target identification range of 10 km with single laser pulse imaging.

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- Demonstrated 480 x 640 array with 20 mk sensitivity.
- Investigated polarization structures, with uncooled arrays.
- Integrated photon and thermal detectors on the same chip, with dual mode read-out.

	FY 2002	FY 2003	FY 2004	FY 2005
Novel Crystal Components for Imaging and Communications	6.000	1.659	0.000	0.000

(U) Program Plans:

- Continue the development of novel crystal components.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA3 Advanced Technology Development	Command, Control and Communications Systems PE 0603760E, R-1 #45

COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	117.007	117.164	242.738	279.855	270.959	330.559	327.504	341.812
Command & Control Information Systems CCC-01	65.690	28.793	49.904	54.629	66.148	132.888	149.354	158.960
Information Integration Systems CCC-02	51.317	68.637	95.926	106.576	106.961	109.926	109.818	114.587
Asymmetric Systems CCC-03	0.000	19.734	40.403	44.429	42.075	29.118	9.762	9.752
Classified CCC-CLS	0.000	0.000	56.505	74.221	55.775	58.627	58.570	58.513

(U) <u>Mission Description:</u>

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The goals of the Command and Control Information Systems project are to develop and test innovative, secure architectures and tools to enhance information processing, dissemination and presentation capabilities for the commander. This will give the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making and execution support capability, and provide secure multimedia information interfaces and assured software to "on the move" users. Integration of collection management, planning and battlefield awareness programs is an essential element for achieving battlefield dominance through assured information systems.

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. The principal element of this project is assured communications using standard and non-traditional means.

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(U) The goals of the Asymmetric Systems project are to fight terrorism by creating a new infrastructure and new information technologies aimed at exposing foreign terrorists and their activities and support systems. Currently, terrorists are able to move freely throughout the world, to hide when necessary, to find unpunished sponsorship and support, to operate in small, independent cells, and to strike infrequently, exploiting weapons of mass effects and media response to influence governments. This low-intensity/low-density form of warfare has an information signature with detectable clues that are generally found after an attack. Elements of the solution include gathering a much broader array of data than we do currently, discovering information from elements of the data, creating models of hypotheses, and analyzing these models in a collaborative environment to determine the most probable current or future scenario.

(U) <u>Program Change Summary:</u> *(In Millions)*

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	115.149	130.101	182.889	225.085
Current President's Budget	117.007	117.164	242.738	279.855
Total Adjustments	1.858	-12.937	59.849	54.770
Congressional program reductions	0.000	-12.937		
Congressional increases	0.000	0.000		
Reprogrammings	1.858	0.000		
SBIR/STTR transfer	0.000	0.000		

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE October 2001
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Applied Research	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, R-1 #45

(U) Change Summary Explanation:

FY 2002	Increase reflects below threshold reprogrammings.
FY 2003	Decrease reflects congressional program reductions.
FY 2004 – 2005	Increases reflect inclusion of classified programs in a newly created project, CCC-CLS, and additional funding for several major communications programs in CCC-02.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA3 Advanced Technology Development	Command, Control and Communications Systems PE 0603760E, Project CCC-01

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Command & Control Information Systems CCC-01	65.690	28.793	49.904	54.629	66.148	132.888	149.354	158.960

(U) Mission Description:

(U) Military operations that have taken place since the end of the cold war have demonstrated that current theater command, control, communications, intelligence/information systems, and planning and rehearsal systems lack the ability to fully support operations in complex, time-critical environments. These operations range from conflict and peacekeeping in urban centers to heavy battle actions in remote areas. Current capabilities do not provide the commander with real time, secure, situational awareness nor the ability to orchestrate high-tempo planning, rehearsal and execution. The goals of the programs in this project are to develop and test innovative, secure architectures and tools to enhance information processing, dissemination and presentation capabilities for the commander. This will give the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making and execution support capability, and provide secure multimedia information interfaces and assured software to "on the move users". Integration of collection management, planning and battlefield awareness programs is an essential element for achieving battlefield dominance through assured information systems.

(U) With the growing dependence on information systems and the pressing need to be able to get the right information to the right person at the right time, it becomes critical to deliver and protect information and assure the availability of associated services – particularly in a stressed environment. Ongoing information security efforts funded in this project are Organically Assured and Survivable Information Systems (OASIS), Active Templates (AcT) Control of Agent Based Systems (CoABS), Genoa, Advanced Sensor/Strike Battle Manager, Advanced Ground Tactical Battle Manager, Effect-Based Network Targeting, Advanced Intelligence, Surveillance and Reconnaissance Management (AIM), Predictive Battlespace Awareness, Banshee, Comprehensive Force Protection, Collaborative Operational Planning Environment and Urban Commander programs.

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(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
OASIS	19.953	17.024	4.800	0.000

(U) The Organically Assured and Survivable Information Systems (OASIS) program seeks to provide defense capabilities against sophisticated adversaries to allow sustained operation of mission critical functions in the face of known and future cyber attacks against DoD information systems. The technology development goals are to conceive, design, develop, implement, demonstrate and validate architectures, tools and techniques that would allow fielding of organically survivable systems. The program will transition technologies that allow systems to continue to operate correctly in the face of successful intrusions and attacks through tolerance and self-healing properties.

(U) The OASIS Dem/Val program takes a systems approach to integrate prevention, detection, response and tolerance technologies into a military system to significantly improve the survivability of the system in the face of a large-scale cyber attack.

(U) Program Plans:
- OASIS.
  - Demonstrate an experimental intrusion tolerant database from commercial-off the-shelf components.
  - Prototype and evaluate a framework for tolerating intrusions in large-scale, heterogeneous, networked computing enterprises.
  - Build a distributed compositional architecture for the deployment of intrusion tolerance mechanisms implementing an explicitly stated but flexible tolerance policy.
  - Develop an integrity and availability framework that combines passive intrusion tolerance and active intrusion recovery mechanisms.

(U) Program Plans:
- OASIS Dem/Val.
  - Integrate OASIS and other DARPA and commercial technologies to develop and demonstrate a survivable variant of the Joint Battlespace Infosphere (JBI).

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-- Demonstrate effectiveness of survivable architectures in the face of a determined cyber attack on critical military information system ensuring continuation of critical functionality through a sustained cyber attack.
-- Validate survivability claims of technologies using recognized methodologies on operational systems and create novel approaches to composing assurance cases for large-scale systems.

	FY 2002	FY 2003	FY 2004	FY 2005
Active Templates	12.018	3.836	2.000	0.000

(U) The Active Templates (AcT) program is producing robust, lightweight software technologies to improve mission planning and execution control for special operations. Active Templates are distributed applications whose variables are linked to live data feeds and external problem-solving algorithms. AcT helps automate planning and execution by capturing, suggesting, and updating critical information such as current state, goals, constraints, alternative actions, standard defaults, decisions in context, and rationale. Active Templates are designed to be easily tailored, networked, noise-tolerant, user-supported, scalable, and widely adopted. As a result, special operations planners will be able to create a plan six times faster, improved plan quality by considering up to eight times more options, reduce staff-hours required to track and coordinate missions by 60 percent, enhance ability to capture lessons learned, and improve national capability to respond in a crisis. Early prototypes of AcT technologies have been adopted and used by Special Operations Command (SOCOM) including Operation Enduring Freedom, where they have been shown to accelerate temporal planning by a factor of four and reduce the number of personnel required for battle tracking by a factor of six. DARPA is working closely with the Joint Special Operations Command on temporal and spatial planning applications and simple forms-based coordination tools that may be defined dynamically by ordinary users in less than a day. Experiments (e.g., time-and-motion studies) with these technologies show improvements in the range indicated above, and SOCOM has approved a program for transitioning these technologies to the theater forces. The Joint Forces Command has agreed to provide training for these new command and control tools.

(U) Program Plans:
- Develop a data representation and template library for critical planning parameters for template adaptation and merging.
- Demonstrate advanced tools for extending term-ontology to avoid duplication and conflicting semantics.

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- Develop a Planning and Execution Shell including tools for template development such as selecting and tailoring dependencies and problem solving algorithms. These tools will also include advanced problem solvers like generative planning, temporal/uncertain reasoning and triggering for complex events.
- Demonstrate temporal, spatial, and forms-based mission planning and execution control tools and measure their effectiveness in special operations exercises.
- Transition to U.S. Special Operations Command (SOCOM) and to all theater special operations commands.

	FY 2002	FY 2003	FY 2004	FY 2005
Control of Agent-Based Systems (CoABS)	11.110	0.000	0.000	0.000

(U) The Control of Agent-Based Systems (CoABS) program developed the ability to rapidly assemble a set of disparate information systems into a coherently interoperating whole without redesigning legacy systems. This enables interoperation with non-DoD governmental systems and open-sourced systems not built to a pre-existing government standard. The development and implementation of mobile agents and agent-communication languages aid in the facilitation of multi-systems integration and in controlling the information flow to alleviate bandwidth saturation and degraded quality of service. The CoABS program demonstrated and deployed a middleware-based approach, and toolkits for rapid creation of capability to support the interoperation of heterogeneous systems in contingency and coalition operations, and thus will enable the interaction of military and non-military resources in these critical operations.

(U) Program Plans:

- Released CoABS Grid code and components tailored to military user needs.
- Demonstrated the scalability of the architecture to support more than 1,000 agents without conflicts.
- Evaluated CoABS in military applications including major joint exercises featuring coalition operations and situation in a significant demonstration.
- Demonstrated the capability of the CoABS technology to support a heterogeneous network of platforms and weapons systems to provide an order of magnitude improvement in naval combat flexibility and operational effectiveness.

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	FY 2002	FY 2003	FY 2004	FY 2005
Genoa	11.499	0.000	0.000	0.000

(U) The Genoa program developed tools and infrastructure for collaborative crisis understanding and management for the national security community. These tools provided a foundation for and transition to Project Genoa II, an integral component of the DARPA Total Information Awareness (TIA) program (both programs are funded in PE 0603760E, Project CCC-03).

(U) Program Plans:

- Completed testing and experiments in user environments.
- Modified Genoa infrastructure as needed in user environments.
- Transitioned components to user agencies such as CIFA/JCAG, JIOC, JFCOM, Army INSCOM, etc.
- Deployed and supported leave-behind prototypes at critical nodes within the intelligence community for use during Operation Enduring Freedom and the continuing war on terrorism.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Sensor/Strike Battle Manager	0.000	3.000	6.000	8.000

(U) The Advanced Sensor/Strike Battle Manager program will help air operations staff conduct complex campaigns with new air platforms that contain precision sensors, precision weapons and communications relays. It will be driven by a) targeting information, both for sensor targets and for strikes, expressed both as point targets and area targets (search, combat air patrol), b) rules of engagement and procedural constraints such as airspace restrictions, and c) availability of platforms, weapons, sensors and communications gear. It will produce ingress routes, flight schedules, and patrol zones while assuring airspace and electronic deconfliction and will allow pilots and commanders to choose either conventional tactics or invent unconventional operations. In the latter case, the system will capture the innovation and make it available for future mission plans. Finally, the system monitors actual plan execution against expected results, and alerts commanders to significant differences, while capturing statistical descriptions of insignificant differences to help assess the robustness of future plans.

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(U) Program Plans:
- Identify a service (Air Force or Navy) training facility where air mission plans are routinely constructed.
- Outfit the facility with software tools and human observers to capture plans as they are constructed, executed and modified.
- Conduct exercises and capture a large set (several hundred) of mission plans as example cases.
- Decompose each plan into plan fragments.
- Assemble groups of similar plan fragments into plan templates.
- Build a large-scale integration algorithm to assemble plan fragments into a synchronized operational plan.
- Build optimization tools to tailor routes, schedule events, and deconflict airspace and radio frequencies.
- Compile standard mission plan products from the optimized operational plan.
- Build tools to correlate actual field events to planned events.
- Evaluate all of these techniques in periodic training events.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Ground Tactical Battle Manager	0.000	3.933	8.000	6.000

(U) The Advanced Ground Tactical Battle Manager program automatically expands operational plans, sketched by commanders of robotic forces, into commands for each tactical vehicle. The battle manager takes into account terrain, restrictive rules of engagement, weather and opponents' capabilities. It constructs contingency plans to anticipate uncertainties in opponents' location and capability, and dynamically replans operations as new information arrives. It is driven by context data describing terrain, weather, vegetation, roads, obstacles, and locations of known and suspected enemy and neutral forces. It generates routes that reflect the commander's guidance on risk versus stealth versus speed. It tailors templates of standard tactics, such as ambushes, bounding overwatch, reconnaissance, or scouting, to current tactical conditions. The program will provide the technology to control entire squads of robotic units on the ground, allowing U.S. personnel to avoid areas of high risk, while maintaining positive control of the vehicles. The Future Combat System (FCS) Multi-cell and Dismounted Command and Control program is but one example of the applicability of this technology to future land forces. The FCS Multi-cell C2 effort is funded in PE 0603766E, Project NET-01, in FY 2004 and subsequent years.

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(U) Program Plans:
- Obtain a representative set of mobile ground robots.
- Identify and make arrangements for conducting multi-vehicle exercises in open, forested and urban terrain.
- Define a functional architecture that includes tactical templates for plans, route generators, event schedulers and synchronization tools.
- Acquire context data for the exercise site, as required by the external interfaces defined in the functional architecture.
- Obtain baseline technologies, perhaps with significant human-in-the-loop elements, for each function in the architecture.
- Perform an exercise with the baseline technology to establish performance benchmarks.
- Identify and address opportunities to improve component technologies.
- Periodically exercise the improvements and iterate.
- Conclude the program with a final field demonstration.

	FY 2002	FY 2003	FY 2004	FY 2005
Effect-Based Network Targeting	0.000	1.000	0.000	0.000

(U) The Effect-Based Network Targeting (formerly Network Effects-based Targeting with Adversarial Reasoning) program is developing technology to identify, find vulnerabilities in, target and anticipate workarounds in enemy networks. These techniques will use all-source information to continuously update models of adversary networks [air defense, military C2, telecommunications, transportation (land, rail, air, water), energy (fuel, coal, electric power), etc.]. This program moves to PE 0603766E, Project NET-01 beginning in FY 2004.

(U) Program Plans:
- Identify real-world examples of complex network effects, in conjunction with existing target analysis organizations.
- Determine the network models required to analyze those effects and the sources of information available to update them.

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	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Intelligence, Surveillance and Reconnaissance Management (AIM)	11.110	0.000	0.000	0.000

(U) The coming generation of collection systems will provide dramatically increased volumes of higher fidelity data to the operational decision-maker. The challenge will be to dynamically manage and synchronize this advanced collection architecture with the next-generation processing, exploitation and dissemination capabilities to provide the critical information to the decision maker in the constantly changing operational situation. The Advanced Intelligence, Surveillance and Reconnaissance Management (AIM) program developed Collection Strategies and Multi-asset Synchronization components to dynamically optimize/synchronize, schedule, and task the space borne, airborne and ground based collection, processing, exploitation and dissemination architecture. The AIM program optimized Intelligence, Surveillance and Reconnaissance (ISR) support to precision engagement and tactical operations by providing proactive information support to the warfighter, continuous integration of operations and ISR, responsive ISR timelines, optimal ISR confederation management, and synchronization of ISR asset and exploitation tasking.

(U) Program Plans:

- Completed integration of AIM capabilities for optimized ISR collection management to provide continuous dynamic and proactive collaboration between operations and ISR.
- Developed user interfaces to include task valuation and prioritization methodologies, and associated metrics in combination with quantitative data driven needs, for use in multi-user/multi-mission environments.
- Completed experimentation/validation of AIM technology in a major military command environment with participation in a command level exercise.
- Developed Information Needs Interface and Deployment Coordinator and Optimizer to provide more robust and versatile capability at the Strategy Developer phase of process.
- Conducted final year assessment and evaluation for military utility, and transition of Multi-Asset Synchronizer to airborne and overhead collection systems including collection management migration systems.
- Developed "front-end" input through use of AIM Deployment Coordinator and Optimizer.
- Eliminated Strategy Developer tool.
- Utilized "Knowledge Capture" techniques to assess program maturity and define future applications/experimentation and transition opportunities.

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	FY 2002	FY 2003	FY 2004	FY 2005
Predictive Battlespace Awareness	0.000	0.000	7.000	10.000

(U) The Predictive Battlespace Awareness program will develop technology to predict the range of an opponent's future actions in able to preposition sensors, weapons and information to counter those actions. It will develop model- and knowledge-based techniques to anticipate major enemy activities, such as prediction of areas of operation, prediction of operational and tactical objectives, and the modeling of large-scale courses of action. Techniques will be developed to support on the fly tailoring of models and contextual knowledge, based on knowledge of sensor effectiveness, mobility factors and tactical templates and target characteristics. Finally, it will develop techniques for variable-fidelity prediction, such as the ability to predict both target locations over minutes and force zones of influence over hours. Tools will be provided that anticipate enemy operations in time to thwart them with effects-based targeting, enabling effective use of sensors and other resources in proactive modes. Commanders will be able to avoid canned responses by rapidly incorporating insights about new enemy strategies, capabilities, and tactics from peacetime to heat of battle. The program will augment and enhance today's mostly manual, slow planning and analysis processes.

(U) Program Plans:

- Survey recent military operations to identify cases where opponent's actions could have been anticipated.
- Define a set of realistic challenge problems, including scenarios and a realistic simulation facility, to illustrate the context and value of predictive battlespace awareness.
- Develop approaches to prediction that combine physics-based modeling (e.g., for mobility and observability) with knowledge-based techniques (e.g., for plan generation or recognition).
- Evaluate alternative approaches against the challenge problems.
- Define a system architecture that combines the best approaches into a consistent, mutually supporting toolkit.
- Integrate selected technologies into the toolkit.
- Demonstrate the toolkit during live-play training exercises.

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	FY 2002	FY 2003	FY 2004	FY 2005
Banshee	0.000	0.000	7.000	11.000

(U) The Banshee program will develop low latency, high capacity data link technology for expendable platforms (weapons, small unmanned air vehicles). The technology will provide robust, secure, capable, miniaturized, flexible, affordable, advanced wireless communication technologies for expendable platforms that is economically integrated into existing control platforms. The link will support multi-point communication among air and ground platforms, including weapons, for guidance, target deconfliction, and rapid accommodation of changes to rules of engagement. Technologies will be developed to address three critical components: 1) a low rate bi-directional link, 2) video rate from weapon link or sensor, and 3) flexible guaranteed low-overhead network communications management. Banshee can provide assured communications from shooters to weapons, enabling in-flight command authority. This will permit targeting and weapon handoff, deconfliction of multiple weapons delivered against clustered target complexes, and provision of endgame imagery for collateral damage mitigation, targeting enhancement and battle damage assessment.

(U) Program Plans:

- Perform system analysis to determine the expected number of simultaneous engagements to be controlled, and the proper bandwidth for the link to the weapon and the number of frames of video data acquired during an engagement.
- Develop and simulate a Banshee network management control system.
- Develop and analyze competing designs that minimize integration and installation costs while meeting performance goals.
- Select two designs for brassboard construction and bench test evaluation.
- Select one design for end-to-end field tests.

	FY 2002	FY 2003	FY 2004	FY 2005
Comprehensive Force Protection	0.000	0.000	4.000	4.000

(U) The Comprehensive Force Protection program will develop a rapidly deployable system to provide assured protection of permanent or temporary U.S. base camps in hostile territory. It will include wide area sensors and platforms to maintain continuous surveillance of the area around the camp, detecting potential intruders or weapon launches. It will also include a suite of airborne sensor platforms that can be tasked

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rapidly to investigate potential threats, or to lock on to personnel or weapons involved in an attack. Data collected from sensors will be automatically analyzed, correlated and provided to commanders to confirm threats, and to authorize precision weapons to engage them. The system will maintain continuous perimeter surveillance, allow rapid investigation and, when authorized, prosecute threats.

(U) Program Plans:

- Review past and forecast threat analyses to characterize intrusions, events, activities, and signatures.
- Select a test area in which data on intrusions can be collected.
- Emplace a variety of sensors, both extant and developmental, into the test site along with a communications network back to a data analysis and command station.
- Collect data on a variety of realistic intrusions in a variety of weather conditions.
- Characterize the performance of candidate signal processing, target recognition and localization, and environment monitoring algorithms on the test data.
- Select a set of algorithms for a baseline system build.
- Construct and calibrate a system performance model for the selected algorithms.
- Exercise the baseline system in the testbed and compare results against the performance model.
- Selectively improve algorithmic components that contribute most to performance gaps.
- Iterate and demonstrate the final system in continuous operation at a CONUS base.

	FY 2002	FY 2003	FY 2004	FY 2005
Collaborative Operational Planning Environment (COPE)	0.000	0.000	6.000	8.000

(U) The Collaborative Operational Planning Environment (COPE) program will develop automated tools to assist ground commander collaboration in the construction of detailed, realistic operational plans. Partial plans will be represented in hierarchical task networks, and visualized through synchronization matrices, icon overlays, or tactical sketch animations. Commanders and staff will modify, refine, and extend the plan through speech, sketching, and semi-structured input. The system will link plan fragments constructed at different sites, transfer information among related parts of the plan, and discover and recommend solutions for inconsistencies. The system will continuously compile a

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set of plan cases, and employ analogical matching to suggest extensions to current plans suggested by past experience. Finally, the system will continuously assess progress against the plan, and alert users to significant deviations.

(U) Program Plans:
- Define a common plan representation, based on service training material, for combined arms operations.
- Construct an initial collection of operational plans, for a variety of scenarios and force structures.
- Develop tools to visualize, edit, modify, and assemble new plans from mixed-mode human interaction at one location.
- Develop mechanisms to define and enforce policies limiting the aspects of a plan deemed relevant to each location.
- Construct protocols to propagate changes made at one location to other affected locations, in accordance with defined policy.
- Build flexible algorithms to match changes received from remote locations to the aspects of a plan retained locally, to detect inconsistencies, and to suggest rectifications.
- Employ structure matching techniques to find analogies between the plan currently under development and previously stored plans, and to suggest amplifications, extensions, or refinements.
- Conduct a series of laboratory evaluations with Army and Marine commanders to assess the quality and utility of the COPE products.
- Transition COPE technology to an on-going service C2 improvement program.

	FY 2002	FY 2003	FY 2004	FY 2005
Urban Commander	0.000	0.000	5.104	7.629

(U) The Urban Commander program will develop planning and control tools tailored to dismounted operations in complex urban environments. Limitations on sightlines and mobility combined with ever-insufficient knowledge of the disposition of enemy combatants, civilians, and the structures they occupy present very challenging tactical planning problems. Urban Commander will create a command and control substrate that enables ground forces, including vehicles and dismounts, to rapidly coordinate actions as the situation, and the forces' knowledge of the situation, change. Elements of the Urban Commander program will include spatial analysis, to determine lines of sight and fields of fire; planning aids, to assist in sensor placement and route planning; visualization tools, to allow commanders and soldiers to rapidly apprehend a situation and plans to deal with it; and analysis tools, to suggest locations and types of potential threats.

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(U) Program Plans:

- Identify a set of urban combat scenarios ranging from peacekeeping to aggressive assault.
- Document sets of mission tasks out of which tactical plans may be constructed.
- Design and implement a suite of tools to analyze the situation, compare it against current plans, and allow rapid assemble of new or branch plans.
- Exercise the tools in computer-assisted wargames to determine opportunities for new tactics or concepts of operation.
- Iterate the process, with annual participation in Marine, Army, or Special Forces field exercises.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Information Integration Systems, CCC-02	51.317	68.637	95.926	106.576	106.961	109.926	109.818	114.587

(U) Mission Description:

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. Through the use of wideband dissemination and integrated sensor management, the project will also facilitate multi-site, real-time, collaborative situation assessment and course-of-action evaluations. This project hosts many of DARPA's most innovative communications systems. Programs funded are: Airborne Communications Node (ACN) program, the Adaptive Waveforms (AW) program, the Connectionless Networks (CN) program, the Adaptive Joint C4ISR Node Advanced Concept Technology Demonstrator (AJCN ACTD), the Next Generation (XG) program, the Advanced Speech Encoding (ASE) program, the Symbiotic Communications program, the Command Post of the Future (CPOF) program, and the Tera Hertz Operational Reachback (THOR) program.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Airborne Comms Node (ACN)/AJCN ACTD	13.988	12.816	9.350	0.000

(U) The Airborne Communications Node (ACN) program will enable an affordable, autonomous communications infrastructure that simultaneously provides assured communications, situational awareness and signals intelligence (SIGINT). ACN payloads can be integrated on platforms ranging from High Altitude Endurance (HAE) unmanned airborne platforms (e.g., Global Hawk) to vessels or ground vehicles. The ACN system will be scalable such that payloads for various platforms can be constructed from a core set of common circuit boards and chassis. The ACN on an HAE platform will provide wide-area wireless communications and SIGINT services over the theater of operation for joint and multinational forces by establishing an early robust airborne infrastructure for intra-theater line-of-site (LOS) and reachback beyond line-of-site (BLOS) situations without the need for large in-theater assets. ACN will augment and enhance the battlefield communications infrastructure in

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order to adapt communications, situational awareness and SIGINT services to the flow of battle. Therefore, the ACN system needs to be adaptable, interoperable, robust, secure, and affordable within the size, weight and power constraints of the intended platforms. Additionally, the ACN architecture allows for the implementation of technologies that can securely adapt the various wireless systems (such as unattended ground sensors (UGS)) and command & control tiers that will exist in the future network centric battlesphere. The ACN system operational utility will be assessed by U.S. Joint Forces Command as part of a Joint ACTD, named the Adaptive Joint C4ISR Node (AJCN), which begins in FY 2003 and completes in FY 2005 with an extended user evaluation in FY2006 – FY2007. The ACTD, which will be jointly funded by DARPA, Army, Air Force, U.S. Joint Forces Command, and the Office of the Secretary of Defense, will integrate ACN payloads onboard Air Force and Army aircraft.

(U) Program Plans:

- Develop technologies for policy based resource management for command & control network centric information systems.
- Demonstrate multi-mission performance baseline in laboratory demonstration.
- Demonstrate initial feasibility of porting the Joint Tactical Radio System (JTRS) waveforms into architecture with the integration of the JTRS 2C waveform.
- Demonstrate feasibility of multi-mission technology with end-to-end demonstration in laboratory.
- Conduct flight test on RC-12 or C-232 to evaluate in-flight co-site mitigation performance.
- Integrate JTRS (Single Channel Ground Air Radio System) SINCGARS waveform within AJCN architecture to demonstrate feasibility of porting JTRS waveforms.
- Initiate development of Concept of Operations, Tactics, Techniques and Procedures (TTP), and training package.
- Integrate AJCN payload and antennas on KC-135 aircraft and the Interim Joint Military Utility Assessment (IJMUA).
- Investigate technologies to provide secure waveforms.
- Investigate technologies to incorporate other systems (such as UGS) into the ACN architecture.

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	FY 2002	FY 2003	FY 2004	FY 2005
Adaptive Waveforms (AW)	0.000	0.000	5.700	12.698

(U) The Adaptive Waveforms (AW) program will address lessons learned from the Airborne Communication Node (ACN) program concerning the need for secure communications waveforms. The AW program will develop and demonstrate an adaptive waveform agile communications system that can change structure (frequency, modulation, data rate, hop rate, code, etc.) on a periodic or aperiodic basis to minimize the probability of detection, interception, and exploitation in order to support covert operations. New means of conducting secure communications are needed because the commercial availability of high performance RF components makes the basic tools necessary for conducting signals intelligence (SIGINT) exploitation available to our adversaries. It is realistic to assume that adversaries will soon have the capability and means to develop software exploitation techniques that make even the most advanced U. S. communications systems vulnerable. To defeat this threat, the technical goal is to eliminate repeatability in transmissions by adapting the waveform randomly and forcing random network routing. In keeping with the multi-INT focus of the ACN program, secondary objectives of the AW program include making the system capable of simultaneously supporting multiple missions, to include communications, SIGINT, radar, and electronic warfare.

(U) Program Plans:

- Initiate system design effort.
- Initiate red team development of commercial-off-the-shelf-based exploitation receiver.
- Analyze processing required and size terminal.
- Demonstrate and assess random network routing performance.
- Develop and demonstrate ability to generate single-mission dynamic waveforms in response to various stimuli (environment, quality of service, data type).
- Demonstrate performance against red team commercial-off-the-shelf-based exploitation receiver.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

	FY 2002	FY 2003	FY 2004	FY 2005
Connectionless Networks (CN)	0.000	0.000	6.700	14.660

(U) In order to bring data efficiently from high value, but energy limited sensors (such as unattended ground sensors (UGS)), into system architectures like that of the Airborne Communications Node (ACN) a new fundamental emphasis must be placed on how these kinds of sensor networks communicate. The Connectionless Networks (CN) program will develop technology to allow networks (such as UGS) to send and receive messages without initial link acquisition or previous sharing of routing information. This will, in turn, improve energy per bit of delivered information by as much as 100 to 1,000 times compared to conventional and near-term deployable communications systems such as contemplated by both commercial and military users. Conventional radio link and network designs expend most of the energy on link establishment and maintenance as well as packet and network overhead. This energy requirement not only limits the lifetime of energy-limited systems, it unnecessarily fills the radio spectrum, limiting available bandwidth, creates unnecessary risks of detection, and increases thermal loads. These impacts are especially severe for communications such as proliferated sensors or remotely operated or updated weapons. Eliminating the requirement to maintain a continuous network linkage would enable these platforms to provide continuous connectivity without consumption of power, or compromising emanations. The CN program will exploit current signal processing components, intelligent (processing and memory intensive) routing, and availability of situational information to demonstrate a total energy savings of at least 100 times typical connection oriented network applications.

(U) Program Plans:

- Investigate specific technology requirements for each of the traditional networking.
- Determine layer specific solutions.
- Investigate layer integrating approaches.
- Model acquisition and Media Access; Network and Transport design; and aggregate energy cost savings.
- Predict achievable performance improvement.
- Develop and evaluate candidate approaches for implementation complexity, on-board processor and memory capability/power, overhead, scalability and performance.

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	FY 2002	FY 2003	FY 2004	FY 2005
Next Generation (XG)	3.479	7.753	16.001	20.241

(U) The Next Generation (XG) program goals are to develop both the enabling technologies and system concepts to provide dramatic improvements in assured military communications in support of a full range of worldwide deployments through the dynamic redistribution of allocated spectrum along with novel waveforms. U.S. Forces face unique spectrum access issues in each country in which they operate, due to competing civilian or government users of national spectrum. These constraints must be reflected in all force planning and may preclude operation of critical systems. Coalition and allied operations are even more complex to manage, and may severely limit the U.S. ability to fully exploit its superiority and investment in information technology. The XG program approach is to develop the theoretical underpinnings for dynamic control of the spectrum, the technologies and subsystems that enable reallocation of the spectrum, and the system appliqué prototypes to demonstrate applicability to legacy and future DoD radio frequency emitters. The approach plans to investigate methods to leverage the technology base in microelectronics with new waveform and Medium Access and Control protocol technologies to construct an integrated system. The proposed program goals are to develop, integrate, and evaluate the technology to enable equipment to automatically select spectrum and operating modes to both minimize disruption of existing users, and to ensure operation of U.S. Systems. The result of the XG program will be to develop and demonstrate a standard protocol appliqué for legacy and future emitter systems for joint service utility.

(U) Program Plans:

- Conduct CONUS and OCONUS Spectrum Usage Analysis.
  - Analyze military bands during Force Exercises.
  - Analyze civilian band usage in a variety of locales (urban and rural settings).
  - Optimize correlation between distributed nodes.
- Investigate concepts for employment and utility of a dynamic waveform to the warfighter.
- Complete initial spectrum characterization of military bands usage.
  - Two to three exercises at 10 plus locations.
  - Establish baseline for analysis.
  - Conduct simultaneous measurements at multiple positions.

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- Conduct Lab Demo of Sense and Adaptation Technology Performance.
  - Perform analysis and simulation of multiple control protocols.
  - Use military band spectrum analysis to assess subsystem technology development.
- Initiate development of testbed for hardware in-the-loop testing of concepts.
- Characterize next generation Electronically Steerable Array antenna, and RF component technology for inclusion into eventual demonstrator.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Speech Encoding (ASE)	2.401	6.669	8.798	7.217

(U) The Advanced Speech Encoding (ASE) program will investigate the reduction of voice communication bit rates in noisy military environments. The program will compress speech to bit rates between 200 bps and 800 bps while producing speech quality at least as good as that produced by the current standard and maintaining that quality and bit rate in noisy military environments. Reduction of voice communication bit rates will decrease the probability of detection of transmitted signals and also decrease the required transmit energy, hence increasing battery lifetime. ASE will reduce voice communication bit rates by directly measuring the glottal excitation function, then combining the measurements with acoustic data to compute physical vocal tract transfer functions. With this information, ASE will employ developed noise suppression algorithms and voice encoders that will use the glottal excitation measurements to transmit at significantly reduced power and/or bandwidth. Reliable authentication of the speaker's identity will also be investigated.

(U) Program Plans:

- Develop noise suppression algorithms.
- Develop speaker authentication features and algorithms.
- Develop prototype chip combining vocal waveform measurement sensor and associated software.
- Demonstrate speaker authentication algorithms that provide low probability of identifying an unauthorized speaker as authorized.
- Demonstrate <1000 bps vocoder using vocal excitation waveform measurements to extract speech information content in noisy environments with speech quality at least as good as current DoD 4800 bps vocoders.

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	FY 2002	FY 2003	FY 2004	FY 2005
Symbiotic Communications	20.236	19.193	17.838	18.759

(U) Future combat systems increasingly rely on accurate intelligence preparation of the battlefield. This includes timely and accurate georegistration of all sensed data for precision weaponry on targets (including mobile targets). The single biggest error source that exists in the georegistration process is the lack of accurate knowledge of the terrain. Current national databases provide only coarse Level 1 data; Level 2 data will become available in the next several years. Neither Level 1 nor Level 2 data is sufficient to take full benefit of even current generation weapon accuracies, and the situation will worsen as weapons navigation and guidance systems improve at a faster pace. In order to overcome this, the Symbiotic Communications (SYCO) program will develop an airborne system that can generate, in real-time, Digital Terrain Elevation Data (DTED) with a precision commensurate with NIMA defined Level 4. This system will operate in all weather and passively. Additional attributes being explored include production of synthetic aperture radar (SAR) imagery and ground moving target indication (GMTI) to facilitate the detection, tracking and engagement of moving targets passively and in all weather conditions. In addition, automated terrain categorization will be investigated that can delineate degrees of wetness and discriminate between fields and trees. Finally, exploration of techniques for using multiple frequencies to achieve enhanced spatial resolution leading to a potential DTED Level 5 precision will be conducted. Initial flight tests have been conducted that demonstrate the basic feasibility of SYCO operating modes and support studies of SYCO measurement phenomenology.

(U) Program Plans:

- Conduct ground experiments for terrain scatter characterization.
- Conduct system analyses and trade studies.
- Develop hardware and conduct planning for early flight tests.
- Investigate terrain classification using polarization, spatial and spectral diversity.
- Investigate high-resolution passive imaging of emitters.
- Investigate potential platforms and begin hardware optimization process.
- Develop data processing architecture and algorithms for non-real time system.
- Conduct flight tests with non-real time system to validate algorithms.
- Demonstrate Digital Terrain Elevation Data (DTED) 3 with non-real-time processing of flight data.

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- Develop real-time airborne system.
- Demonstrate DTED Level 4 with real-time processing of flight data.

	FY 2002	FY 2003	FY 2004	FY 2005
Command Post of the Future (CPOF)	4.958	3.726	0.000	0.000

(U) In current tactical operations, ground commanders conduct operations with a situational awareness that measures around 27 percent to 50 percent of ground truth. This uncertainty, often called the 'fog of war', slows down and degrades the quality of command decisions. Radical improvements in situational awareness are necessary for effective tactical operations. The objective of the Command Post of the Future (CPOF) program is to improve the speed and quality of command decisions, more effectively disseminate command decisions, and reduce the number of staff members required to process and manage the information systems. Three important command functions will be addressed to achieve this objective: 1) improved speed and quality of situation awareness; 2) improved speed of course of action (COA) development and selection; and 3) improved clarity of COA communication between commander and subordinates. For each of these command functions, CPOF is developing technologies that leverage the expertise of the commander by exploiting and augmenting natural cognitive abilities. The key technologies to be developed are: (1) an integrated visualization environment for the commander and his staff; (2) a powerful and comprehensive human-computer interaction capability; (3) a robust collaborative communication environment for creating shared understanding among commanders and staff through both voice and visual interactions; (4) an integrated suite of systems to automate many of the lower level staff functions and automatically invoke and operate supporting, planning and analysis applications; and (5) a modular, portable suite of software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of tactical command.

(U) Program Plans:

- Complete the final experiments in cognitive principals of visualization, multi-modal interaction, collaborative planning and command decision-making.
- Complete technology development of CPOF component technologies of dynamic visualization, multi-modal interfaces and collaborative planning.

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- Integrate final component technologies and knowledge bases into the final prototype commander's mobile interactive display system, the BattleBoard; qualify system capabilities.
- Conduct validation experiments with the Army's Stryker Brigade Combat Team #2 at Ft. Lewis.

	FY 2002	FY 2003	FY 2004	FY 2005
Tera Hertz Operational Reachback (THOR)	6.255	18.480	31.539	33.001

(U) The Tera Hertz Operational Reachback (THOR) program, previously funded in program element (PE 0603760E, project CCC-01), will mature required technologies and credibly demonstrate a system able to provide a high data rate (internet-like) backbone to the tactical user whether airborne, terrestrial, or maritime. By focusing on the militarily unique need for a truly mobile and deployable high-data-rate infrastructure that extends access to existing commercial and military terrestrial fiber infrastructures, the Department's vision of a "Global Grid" will be enabled by creating the high-data-rate nexus among the terrestrial, space, and air grids. This is expected to be accomplished by leveraging the commercial global optical fiber network, multi-quantum well retro-reflectors, and advances in optical phased array technology that have been motivated by directed energy applications. Together, these technologies enable the creation of a hybrid fiber-free space optical network extension. Gigabit-per-second connectivity and long-haul reachback to and between deployed theater command nodes, airborne, and maritime assets will be demonstrated in the final year of the program.

(U) Program Plans:

- Commence development of a high power laser source by phase combining multiple inexpensive lasers used by the telecommunications industry.
- Initiate mobile free-space optical communication subsystem laboratory demonstrations and simulations.
- Execute development of a passive optical terminal.
- Investigate the use of steerable agile beam technology to eliminate the gimbals.
- Conduct system trade study for a maritime terminal.
- Extend the advantages of High Data Rate fiber to the mobile expeditionary warfighter whether on land or sea.
- Provide free space optical connectivity from a terrestrial Point of Presence into the theater of operations via air relay.

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- Provide large reductions in size, weight, and prime power consumption over state of the art systems.
- Demonstrate end-to-end system concept for the warfighter.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-03

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Asymmetric Systems CCC-03	0.000	19.734	40.403	44.429	42.075	29.118	9.762	9.752

(U) Mission Description:

(U) Currently, terrorists are able to move freely throughout the world, to hide when necessary, to find unpunished sponsorship and support, to operate in small, independent cells, and to strike infrequently, exploiting weapons of mass effects and media response to influence governments. This low-intensity/low-density form of warfare has an information signature, albeit not one that our intelligence infrastructure and other government agencies are optimized to detect. In all cases, terrorists have left detectable clues that are generally found after an attack. To fight terrorism, we need to create a new infrastructure and new information technology aimed at exposing foreign terrorists and their activities and support systems. This is a tremendously difficult problem, because terrorists understand how vulnerable they are and seek to hide their specific plans and capabilities. Terrorist's use of camouflage and deception reduces their signature and introduces great uncertainty in the interpretation of any data collected. Once an information leak is discovered, terrorists can adapt quickly to stop it, either by changing tactics or re-organizing in some way.

(U) The key to fighting terrorism is information. Elements of the solution include accessing and sharing a much broader array of intelligence data than we do currently, discovering information from elements of the data, creating models of hypotheses, and analyzing these models in a collaborative environment to determine the most probable current or future scenario. DARPA has sponsored research in some of these technology areas, but it has become clear that additional research and development is warranted to accelerate, integrate, broaden, and automate current approaches. The Asymmetric Systems project (CCC-03) emphasizes the DARPA commitment to improving DoD's counter-terrorism capabilities and provides funding for the Total Information Awareness (TIA) and Genoa II programs.

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(U) <u>Program Accomplishments/Planned Programs:</u>

	FY 2002	FY 2003	FY 2004	FY 2005
Total Information Awareness (TIA)	0.000	9.233	20.000	24.519

(U) The Total Information Awareness (TIA) program will develop and integrate information technologies into a prototype network to aid in countering terrorism through prevention. If successful, the TIA network will predict and, hence, enable preemption of foreign terrorist activity. The TIA program will develop architectures for 1) seamless and transparent access to multiple, physically distributed, heterogeneous databases which already exist within DoD and the Intelligence Community, 2) new information security technologies to ensure personal privacy of U.S. citizen data and confidentiality of intelligence sources and methods, and 3) integrating algorithms and mixed-initiative analytical tools. TIA will develop radically new approaches to applying the capabilities of signal and information processing to the problem of automated detection of terrorist activity; will create innovative technology to support analysis within an improved counter-terrorism network architecture; and will develop revolutionary new models, algorithms, methods, tools, and techniques for summarizing raw analysis into actionable intelligence and options for senior decision makers. TIA research will not involve or give access to any data to which the intelligence community does not already have lawful access. The following components developed under other DARPA programs will also transition into TIA as they mature: Genoa II, Genisys, Genisys Privacy Protection, Evidence Extraction and Link Discovery, Wargaming the Asymmetric Environment, Translingual Information Detection, Extraction, and Summarization, Human Identification at a Distance, and Bio-event Advanced Leading Indicator Technology (Bio-ALIRT, previously referred to as Bio-Surveillance).

(U) Program Plans:

- Identify, assess, and evaluate various emerging information technology and CONOPS for TIA requirements for both infrastructure (e.g., web and grid services) and applications (e.g., automated information search, discovery, filtering, detection, cueing, alerting, predictive behavior and intent).
- Explore concepts and repositories for models, algorithms, methods, tools and techniques for analyzing and correlating data sources applicable to counter terrorism.
- Develop enhanced TIA prototypes, metrics, and experiments for evaluation.

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- Harden and mature fragile complex TIA network technology (infrastructure and applications) and corresponding CONOPS successfully demonstrated and assessed within experiments.
- Plan and execute threat-based red teaming experiments (based on DoD Adaptive Red Teaming concept) spanning various types of terrorist attacks, CONOPs, and information signals.
- Develop new approaches for processing front-end data that take into account source data analysis, the front-end functional and processing pipeline, the influence on the processing pipeline from new information discovery, and the design for embedded simulation, measurement and testing.

	FY 2002	FY 2003	FY 2004	FY 2005
Genoa II	0.000	10.501	20.403	19.910

(U) The Genoa II program is focusing on the information technology support needed by teams of intelligence analysts and operations and policy personnel as they attempt to anticipate and preempt asymmetric threats to U.S. interests. Needed are faster systems of humans and machines, ways to overcome the biases and limitations of the human cognitive system, "cognitive amplifiers" that help teams of people rapidly and deeply understand complicated and uncertain situations, and methods to more effectively distribute data residing in existing stovepipe information repositories. Genoa II will provide technologies to make the teams faster, smarter, and more collaborative. The project will apply automation to team processes so that more can be accomplished sooner. It will develop and deploy cognitive aids that allow humans and machines to think together about complicated problems, and it will override the barriers inherent in today's information stovepipes by creating a dynamic, adaptable, peer-to-peer collaborative environment that supports the necessary co-existence of hierarchical and network organizations. Genoa II's products will be deployed to the Information Awareness Center at U.S. Army INSCOM.

(U) Program Plans:

- Design faster systems by assimilating new information technologies to operational agencies.
- Develop tools for cognitive amplification by extending the ability of software to model current states, estimate plausible futures, support formal risk analysis, and provide for automated option planning. Supporting technology includes the use of intelligent agents, cognitive machine intelligence, associative memory, neural networks, pattern matching, Bayesian inference networks, and biologically inspired algorithms.

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- Develop tools for cross-agency collaboration designed to operate across existing hierarchical organizations while maintaining control and accountability. Areas under consideration will include: knowledge management; corporate memory; context-driven, declarative-policy enforcement; self-aware data; business rules; self-governance; and automated planning.
- Develop a basic suite of evidential reasoning tools that enable analysts to construct reason about and explain structured arguments.
- Develop a basic peer-to-peer collaboration capability to form and manage, ad-hoc, cross-organizational teams.
- Develop enhanced evidential reasoning tools for hypothesis comparison, argument critique, analogical reasoning, scenario generation, stochastic option generation, and storytelling.
- Develop enhanced collaboration tools to provide an initial “center-edge” collaboration environment, including context-based business rules, workflow management, Social Network Analysis (SNA)-based team management, consensus analysis, and knowledge-based security filters.
- Develop a full suite of logic-based and probabilistic-based evidential reasoning tools for simple, complex, and chaotic situations.
- Develop a complete center-edge collaboration environment with a full suite of evidential reasoning, scenario generation, and explanation capabilities.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, R-1 #46

COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	190.133	217.378	342.914	354.877	349.565	365.931	348.959	357.163
Guidance Technology SGT-01	35.258	38.991	33.169	29.423	32.291	31.268	31.237	31.207
Aerospace Surveillance Technology SGT-02	20.145	34.388	24.114	31.875	27.888	30.779	30.749	30.720
Air Defense Initiative SGT-03	18.676	20.657	25.039	31.861	27.398	29.314	34.167	34.133
Sensors and Exploitation Systems SGT-04	116.054	123.342	144.852	130.637	127.867	147.545	148.610	178.463
Classified SGT-CLS	0.000	0.000	115.740	131.081	134.121	127.025	104.196	82.640

(U) Mission Description:

(U) The Sensors and Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing the system oriented technologies necessary to enhance sensor and weapon system accuracy and capability to meet current and emerging threats. Four projects are funded in this program element: Guidance Technology, Aerospace Surveillance Technology, the Air Defense Initiative, and Sensors and Exploitation Systems.

(U) The Guidance Technology project will increase the ability of Global Positioning System (GPS) users to operate effectively in presence of enemy jamming; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems. Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and

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in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this program.

(U) The Aerospace Surveillance Technology project funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, low-power high-performance computing, and low-cost microelectronics to develop advanced surveillance and targeting systems. Surveillance is not an end to itself, but rather an enabler for force protection and precision strike. Therefore, a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) The Air Defense Initiative project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These technology developments are embodied in the Low-Cost Cruise Missile Defense (LCCMD), Global Eye, Affordable Large Array (ALA), Lightfoot Radar and the Innovative Space-Based Radar Antenna Technology (ISAT) programs.

(U) The Sensors and Exploitation Systems project funds the development and demonstration of advanced sensors and systems to exploit sensor products. These efforts, in conjunction with those described in Projects SGT-01, SGT-02 and SGT-03, seek to develop the systems needed to provide the warrior with situational awareness and precision target identification and attack capability, with particular emphasis on the most stressing threats. The strategic goals of this project are to: develop key sensor technologies required to support battlefield dominance, including sensors that can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic exploitation of wide-area moderate (and high) resolution imagery; provide real-time, accurate Battle Damage Assessment (BDA); and provide robust, precise and reliable identification, precision fire control tracking and engagement of high value units, and critical moving targets. These goals are being addressed by the following programs: Counter CC&D; Affordable Moving Surface Target Engagement (AMSTE); Organic Ground Moving Target Identification (GMTI) Radar (OGR); Eyeball Program; Real-Time Battle Damage Assessment (R/T BDA); Tactical Targeting Network Technologies (TTNT); Dynamic Tactical Targeting (DTT); Knowledge Aided Sensor Signal Processing and Expert Reasoning (KASSPER); Forester (formerly Dynamic Tactical Sensing); Exploitation of 3-D Data (formerly Exploitation of Precision Data); Tactical Sensor Network Technologies; Micro-Sensor Fields; Standoff Precision ID in 3-D (SPI 3-D); Video Exploitation Technology; Wide Area All Terrain Search Radar

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(WATSR); Synthetic Aperture Ladar for Tactical Imaging (SALTI); Frequency Diverse Spatial Spectral Sensor Exploitation; and National Tactical Exploitation.

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

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	192.095	224.000	216.840	200.430
Current President's Budget	190.133	217.378	342.914	354.877
Total Adjustments	-1.962	-6.622	126.074	154.447
Congressional program reductions	0.000	-16.622		
Congressional increases	0.000	+10.000		
Reprogrammings	-1.962	0.000		
SBIR/STTR transfer	0.000	0.000		

(U) Change Summary Explanation:

FY 2002	Decrease reflects below threshold reprogrammings.
FY 2003	Decrease reflects congressional program and undistributed reductions offset by an add for the Large Millimeter Telescope.
FY 2004 – 2005	Increases reflect reallocation of portions of PE 0603765E to the newly created SGT-CLS project and Agency reprioritization of resources to support sensor development and application.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA3 Advanced Technology Development	Sensor and Guidance Technology PE 0603762E, Project SGT-01

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Guidance Technology SGT-01	35.258	38.991	33.169	29.423	32.291	31.268	31.237	31.207

(U) Mission Description:

(U) Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this program. Thrusts are included in this project to increase the ability of Global Positioning System (GPS) users to operate effectively in the presence of enemy jamming; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Global Positioning Experiments (GPX)	9.186	8.000	0.000	0.000

(U) The Global Positioning Experiments (GPX) program will increase the ability of GPS users to operate effectively in the presence of enemy jamming or countermeasures by demonstrating the feasibility of airborne pseudolite (APL) concepts. By receiving and re-transmitting GPS signals at substantially higher power levels, the APL will overcome the effects of jamming on DoD receivers and enable continuous operation. APLs can be rapidly deployed on unmanned aerial vehicles (or other airborne platforms) and provide theater-wide coverage for individual soldiers, combat platforms and precision GPS-guided shoot-to-coordinate weapons. The program is addressing three key challenges. First, it is demonstrating non-Keplerian orbit predictions of the APL and showing that only software modifications are needed for GPS user receivers. Second, the APL is accurately navigating using GPS satellites in the presence of jamming. A demonstration was conducted of a digital adaptive

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beamformer integrated with a pseudolite in a GPS jamming environment in both a full scale anechoic chamber and full scale field test, with greater than 45 dB nulls against up to six different jammers. Third, the program is minimizing the impact of APL technology on friendly, unmodified receivers and maximizing interoperability through development of advanced waveforms, demonstration of an advanced beam shaping transmit antenna, precise management of the radiated power, and the associated command and control structure. The GPX program will culminate with integrated demonstrations of APL capability in military exercises. In addition, APL methods will be investigated for exploitation of signals from satellites of opportunity for precision localization in the absence of GPS.

(U) Program Plans:
- Fabricate and integrate multiple airborne pseudolites.
- Conduct airborne testing campaign; demonstrate successful navigation and interoperability in GPS jamming environment using multiple airborne pseudolites.
- Demonstrate shaped transmit beam solution to near-far issue.

	FY 2002	FY 2003	FY 2004	FY 2005
Microelectromechanical Sensor Inertial Navigation System (MEMS INS)	2.207	1.900	1.500	0.000

(U) The Microelectromechanical Sensor Inertial Navigation System (MEMS INS) program will improve the silicon based, inertial sensors (gyros and accelerometers) developed in the MEMS technology program and integrate them with navigation software into a low power, small, lightweight, low cost, tactical grade (1.0 degree per hour to 10 degrees per hour drift rate) INS. In addition to handheld applications, the MEMS INS will be generic for insertion/embedding into other military systems. MEMS INS Phase 1 performed the following: (1) design and development of higher performance MEMS inertial gyroscope and accelerometer sensors, (2) selection and refinement of foundries/foundry processes, (3) design of the mechanical subsystem, and (4) selection/refinement of the navigation software. Phase 2 will develop the MEMS inertial sensors brassboard, integrate them into a MEMS INS and demonstrate the brassboard in the field. MEMS, meso gyro and high accuracy Advanced Gyroscope technologies will be evaluated for suitability to military applications.

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(U) Program Plans:

- Deliver MEMS inertial measurement unit to the DoD.
- Complete field demonstration of MEMS INS navigation capabilities.
- Investigate novel INS designs for very large structures that exploit large baseline separation.
- Investigate MEMS and meso suitability to space applications.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Tactical Targeting Technology (AT3)	13.865	10.061	1.469	0.000

(U) The Advanced Tactical Targeting Technology (AT3) program will demonstrate a passive tactical targeting system against short-dwell emitters to enable lethal suppression of enemy air defenses (SEAD). The targeting system will negate emitter shutdown tactics now employed to defeat anti-radiation missiles (ARM) guidance and enable simplified ordnance inventories. Generation and distribution of near real-time, comprehensive, and highly precise location of threat radars to all theater combatant aircraft is required without deploying any additional SEAD-dedicated, emitter-collecting platforms. AT3 will accomplish this by widely deploying emitter collection packages hosted on existing airborne platforms, including combat aircraft. AT3 will integrate distributed multi-platform emitter collections in real-time using existing or planned tactical data links with advanced network management and signal processing. To achieve wide deployment, AT3 will focus on transition through inexpensive digital upgrades to existing radar warning receivers. Enabling technologies now in development at DARPA and elsewhere will be used, including: highly precise tactical clocks; tightly coupled integrated GPS/INS packages; novel communications waveforms; advanced highly dynamic data fusion network management capabilities; and algorithms to ensure robust, flexible performance of geolocation algorithms for locating multiple emitter types in noisy, high pulse density environments. AT3 has successfully completed initial ground testing with brassboard hardware and has conducted strenuous flight tests and real-time multi-ship demonstrations.

(U) Program Plans:

- Demonstrate AT3 technologies and capabilities.
- Support transition to Air Force and Navy.

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	FY 2002	FY 2003	FY 2004	FY 2005
MEDUSA	10.000	19.030	23.700	19.613

(U) The Multifunction Electro-Optics for Defense of U.S. Aircraft (MEDUSA) program will develop the technologies and systems to give the U.S. air dominance at low altitude and at night. This program will develop the technologies to leap-frog reactive end game countermeasures and enable increased threat warning times, denial of launch, and put EO-IR air defense threats at risk. MEDUSA is a three-part technology program: (1) conduct phenomenological measurements and develop countermeasures and target classification/identification techniques; (2) develop critical component technologies such as high power IR laser sources, advanced IR detectors, and fibers for high power IR transmission; and (3) competitively develop and demonstrate an end-to-end MEDUSA system.

(U) Program Plans:

- Develop and evaluate MEDUSA countermeasure and classification techniques and conduct phenomenological measurements.
- Initiate critical component and system technology development.
- Complete measurements database and development of countermeasures and classification techniques.
- Fabricate and evaluate critical component technologies.
- Develop MEDUSA system designs.
- Build a flyable brassboard system.
- Field test and flight test the brassboard system against realistic targets and environments.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Gyroscopes	0.000	0.000	6.500	9.810

(U) The Advanced Gyroscopes program will develop very high-accuracy gyroscopes for extremely precise navigation, with a goal of reducing gyroscopes noise error to 10^{-5} degree/hour or less. This technological leap will enable more robust operations of several magnitudes – from underwater (including covert submarine operation and littoral navigation around obstacles) to outer space (from space flight to precise, autonomous satellite positioning). Technical challenges include the exploitation of quantum effects, such as correlated photons.

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(U) Program Plans:

- Evaluate feasibility of underlying approach in the laboratory.
- Develop breadboard gyroscopes and test for ultra-low noise and angle random walk.
- Conduct accelerated life testing.
- Design, build, and test fieldable prototype.

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

- Not Applicable.

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<tr><td>COST (In Millions)</td><td>FY 2002</td><td>FY 2003</td><td>FY 2004</td><td>FY 2005</td><td>FY 2006</td><td>FY 2007</td><td>FY 2008</td><td>FY 2009</td></tr>
<tr><td>Aerospace Surveillance Technology SGT-02</td><td>20.145</td><td>34.388</td><td>24.114</td><td>31.875</td><td>27.888</td><td>30.779</td><td>30.749</td><td>30.720</td></tr>
</table>

(U) Mission Description:

(U) This project funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, low-power high-performance computing, and low-cost microelectronics to develop advanced surveillance and targeting systems. Surveillance is not an end to itself, but rather an enabler for force protection and precision strike. Therefore, a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Counter-Underground Facilities	11.441	14.202	14.114	15.200

(U) Underground Facilities (UGFs) are being increasingly employed to hide a variety of strategic functions, including command and control and activities associated with weapons of mass destruction. The Counter-Underground Facilities (CUGF) program is developing technologies to characterize UGFs: identification of facility function, pace of activity, pre-attack status of the facility, trans-attack activities and post-attack status. Techniques are being developed to determine locations of critical systems (power, water, airflow vents), orientation and depth of structure, and pre-strike and post-strike changes in the substructure resulting from attack. This program will develop both the scientific modeling foundation and the enabling technologies and systems to exploit near-field acoustic, seismic and electromagnetic (EM) underground facility signatures and their cross-mode coherence. Additionally, techniques are being evaluated for effluent detection and monitoring. Candidate technologies within this program include, but are not limited to, low frequency electromagnetics, multi/hyperspectral imaging, seismic imaging, chemical sampling, and

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coherent passive seismic, acoustic and electromagnetic monitoring. The CUGF program will develop and demonstrate a functional (non-form factored) sensor system capability including communications for monitoring critical activities and target localization and detailed characterization in support of facility standoff and ground. A companion ACTD effort, the Tactical Missile – Penetrator (TACM-P) program, will demonstrate integration of the Army Tactical Missile System (ATACMS) booster with a Navy reentry vehicle to provide a high-availability, all-weather, survivable and short response time means to destroy hard and deeply-buried targets. U.S. Pacific Command is the operational sponsor.

(U) Program Plans:

- Complete signature data collection and characterization of geophysical site properties of UGFs.
- Complete model validation for seismic, acoustic, electromagnetic and effluent signatures and backgrounds and for effluent modeling tools.
- Demonstrate functional prototype of multi-mode sensor system, using laboratory-quality instruments.
- Develop component technologies for a deployable system, including low-mass, seismic coupling of vibration sensors, site-adaptive non-line of sight communications, and improved deployable EM sensors.
- Evaluate concepts for effluent-based vent hunting and cave exploration.
- Develop candidate sensor designs for effluent-based characterization.
- Develop multi-sensor characterization tool for planning and targeting.
- Finalize design, decouple, and interface nine missile boosters from Block 1 to Block 1A in support of TACM-P.

	FY 2002	FY 2003	FY 2004	FY 2005
Digital Radio Frequency Tags (DRAFT)	4.180	10.347	10.000	16.675

(U) The Digital Radio Frequency Tags program will develop a flexible, potentially low cost technology to allow radars (Moving Target Indicator (MTI) and Synthetic Aperture Radar (SAR)) to receive data from ground devices. This program will develop a small, lightweight and affordable RF Tag for data exfiltration from unattended ground sensors and communication with vehicles and personnel throughout the battlespace. This is particularly useful for the identification and location of coalition units. Other advanced tag capabilities will be investigated and developed, adding additional communications capabilities to the tags for enhanced interoperability with combat identification and communications systems. These added capabilities will give the tags dual-mode capability to function as a tag when radar is present or as a more

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conventional radio beacon device when radar is not available. Additionally, small-scale tag variations will be considered for other missions, including dismount and non-cooperative red target tracking, with the net effect of substantially enhancing situational awareness and combat identification advantages for U.S. forces in conventional and unconventional ground operations.

(U) Program Plans:
- Complete 10 baseline radar tag prototype units.
- Complete design of advanced tag concepts.
- Conduct laboratory device testing and characterization.
- Conduct airborne field tests and user demonstration.
- Complete dual-mode tag communicator design.
- Demonstrate dual-mode tag communicating on SATCOM waveform.
- Develop dismount/red tag prototypes and conduct laboratory device testing and characterization.

	FY 2002	FY 2003	FY 2004	FY 2005
Space Surveillance Telescope	3.024	0.000	0.000	0.000

(U) The Space Surveillance Telescope program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. The program will leverage recent advances in curved focal plane array technology and large, light-weight optics to build a telescope with a large aperture that provides detection sensitivity with a low-aberration wide field-of-view to provide rapid wide-area search coverage. Advances in lightweight optics will reduce the size and weight of the telescope, providing fast slewing and further increasing search rates. This capability will enable ground-based detection of un-cued objects in space for purposes such as asteroid detection and other defense missions. In FY 2003 and out, this program is funded from PE 0603285E, Project ASP-02, Space Programs and Technologies.

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(U) Program Plans:
- Complete telescope design.
- Complete focal plane design.
- Fabricate and tested first curved focal plane tile.

	FY 2002	FY 2003	FY 2004	FY 2005
Large Millimeter Telescope	1.500	9.839	0.000	0.000

(U) The Large Millimeter Wave Telescope (LMT) program is the U.S.-complement to a coordinated U.S.-Mexico project. The DARPA program provided technology assessments for design, systems integration and technology-leading metrology for a 50-meter aperture, fully steerable millimeter wave radio telescope. The fully developed telescope will feature a sophisticated laser metrology system to maintain precise alignment of the optics, and real-time closed loop adaptive control to maintain a near-perfect parabolic surface at all pointing angles and under most environmental conditions.

(U) Program Plans:
- Continued fabrication of metrology panel and surface.
- Continued development of antenna holography system and precision pointing.
- Initiated system integration for construction of base line telescope.

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

- Not applicable

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Air Defense Initiative SGT-03	18.676	20.657	25.039	31.861	27.398	29.314	34.167	34.133

(U) Mission Description:

(U) This project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These technology developments are embodied in the Low-Cost Cruise Missile Defense (LCCMD), Affordable Large Array (ALA), Lightfoot Radar, Global Eye, Innovative Space-Based Radar Antenna Technology (ISAT) Study, and RF MEMS Improvement programs.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Low-Cost Cruise Missile Defense (LCCMD)	7.676	9.357	10.039	10.000

(U) The LCCMD program will design, develop, demonstrate and transition an affordable electronically scanned array (ESA) seeker for use on a missile interceptor system to defeat unsophisticated air vehicles. Unsophisticated air vehicles are affordable, can be procured in large numbers to overwhelm U.S. defenses and provide a credible long-term threat to both civilian population centers and military targets. To reduce the cost of defending against such threats, it is crucial to reduce the cost of the guidance and control sections of defensive weapons. The LCCMD program will enable this through analyses, laboratory testing and field-testing of an all-weather seeker costing less than fifty thousand dollars in production. The program has pursued six novel concepts and is presently focused on the maturation and demonstration of radar seeker solutions employing active ESA concepts using low cost single-chip transmit/receive modules. In addition, the program is developing low-cost surveillance systems to provide the warning/cue for such interceptors.

(U) Program Plans:
- Conduct MEMS ESA seeker systems requirements and developed conceptual designs.
- Initiate MEMS modeling effort and MEMS design improvement/packaging studies for enhanced reliability RF MEMS switches.
- Fabricate, test, and integrate an ESA seeker antenna and seeker back-end in preparation for ground or flight test.

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- Conduct ground or flight test (in collaboration with service transition partner).
- Initiate systems design for low-cost surveillance approaches to provide cue for low-cost interceptors.
- Conduct field measurements to support performance characterization of surveillance systems.
- Design and build prototype surveillance system for a small-scale feasibility demonstration.

	FY 2002	FY 2003	FY 2004	FY 2005
Affordable Large Array (ALA)	2.000	5.000	2.000	0.000

(U) The Affordable Large Array (ALA) program (previously the MEM-tenna program) is developing ultra-low cost, lightweight, and low-power density X-Band transceivers and related technologies for potential use in conjunction with very large but foldable and easily transportable antenna apertures. The overall objective of the program is to develop and demonstrate these transceivers for population of very large, lightweight, active electronically scanned radars that could meet the future DoD needs of a wide variety of radar systems. Low-power, high efficiency, lightweight transceiver module technologies offer the important benefits of being able to operate reliably without the need for liquid or forced air cooling. As a result, significant fuel supply, prime power, weight and cost development of large transportable antennas populated with extremely lightweight transmit/receive (T/R) chips, dynamic calibration of these large flexible arrays, and effective distribution of wideband RF, DC power, and control signals throughout them, without adding appreciably to their weight, all represent significant technical challenges. Other potential applications of ALA technologies include easily transportable, less expensive Ground Based Radar systems and aerostat-based systems for observing very low flying targets. It may also be possible to replace hard-wired beam steering control and RF manifolds by optical and RF space-fed configurations, which will result in additional significant savings in cost and weight.

(U) Program Plans:

- Conduct studies and experiments to develop alternative array feed technologies that are applicable to very large arrays.
- Evaluate alternate solutions, (e.g., SiGe, InP, Si on insulator, and low-power GaAs, as potential low cost/low power density radar transceiver technologies).

- Conduct power-aperture trade studies to determine the appropriateness of these technologies for applications including ground-based radars, radars for mid-course cruise missile defense and airborne low-power-density, large-scale radars.
- Develop and fabricate a minimum of 10 transmit/receive (T/R) cells from SiGe 10 transmit/receive (T/R) cells from InP and 10 (T/R) cells from GaAs for independent test, evaluation and performance comparison.

	FY 2002	FY 2003	FY 2004	FY 2005
Lightfoot Radar	0.000	0.000	6.000	9.000

(U) The Lightfoot Radar program will develop antenna technologies to enhance the transportability of sensor and communications systems. Program goals are the reduction in total system weight, stowed volume, prime power consumption, fuel requirements, and personnel requirements. The technology will potentially benefit sensor and communications systems that are space-based, airship-based, ground-based, and hand-held. Four technical solution paths will be explored. (1) Large low-power antennas to replace fuel-hungry, high-power antennas. (2) Semi-flexible antennas to replace heavy rigid antennas. (3) Terahertz frequency antennas to replace large gigahertz frequency antennas. (4) Passive reflective arrays to replace heavy power-hungry active arrays.

(U) Program Plans:

- Develop large-scale signal distribution and single chip electronics technologies to enable extremely large low-power active array antennas.
- Develop lightweight tensional structures and dynamic calibration techniques to enable semi-flexible active array antennas.
- Develop terahertz sources and signal processing techniques to enable hand-held sensors.
- Develop discrete switches or bi-state materials to enable steerable reflect arrays.

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	FY 2002	FY 2003	FY 2004	FY 2005
Global Eye	3.000	1.000	0.000	0.000

(U) The Global Eye program developed lightweight low-cost electronically scanned array (ESA) technology capable of supporting multiple simultaneous radar modes and frequencies through the use of mono-static or pseudo-mono-static apertures operating in a simultaneous transmit and receive (STAR) mode. Platforms outfitted with this capability provide lower cost continuous air and ground surveillance of low intensity areas such as no-fly zones and peacekeeping areas. Such capability could supplement traditional AWACS and JSTARS and potentially reduce the requirement to forward base large numbers of such aircraft for these purposes. The key technologies developed included an X-band proof-of-concept ESA risk reduction array capable of supporting up to a 100% transmit duty factor using currently available transmit/receive (T/R) modules, beam polarization diversity, and advanced mode control/interleaving algorithms.

(U) Program Plans:

- Completed the building and testing of demo array.
- Demonstrated pseudo-mono-static ESA operation using a 1 sq ft risk reduction array and a separate X-band receive aperture.
- Evaluated its ability to support multiple-mode, multiple-frequency, and radar operation during ground testing with a Moving Target Simulator (MTS) and a mechanically scanned receive aperture.

	FY 2002	FY 2003	FY 2004	FY 2005
Innovative Space-Based Radar Antenna Technology (ISAT)	6.000	0.000	0.000	0.000

(U) Ultra-low cost, lightweight technologies offer the potential for developing and deploying extremely large antennas in space. Antennas of 100 – 300 meters in length, if feasible and affordable, will enable the revolutionary performance required to conduct true tactical sensing from space. The ISAT program will develop conceptual designs for understanding the feasibility of deploying and operating extremely-large-antenna designs capable of performing tactical sensing from space. FY 2003 and subsequent activities for ISAT activities are funded in Program Element PE 0603285E, Project ASP-02.

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(U) Program Plans:

- Developed three competing conceptual designs of antenna systems capable of tactical sensing from space, including performance and cost models for each candidate design.
- Modeled and simulated rigidized inflatable technologies, including subscale laboratory testing.

	FY 2002	FY 2003	FY 2004	FY 2005
RF MEMS Improvement	0.000	5.300	7.000	12.861

(U) RF MEMS switches in the X, Ka, and Ku band hold great promise for DoD radar applications due to their inherent small size, light weight, low power consumption and low loss. The RF MEMS Improvement program will extend lifetimes, develop inexpensive packaging techniques, and enhance RF performance of RF MEMS switches to allow use in devices such as phase shifters, reconfigurable apertures, and tunable filters. This program was previously funded in PE 0603739E, Project MT-12.

(U) Program Plans:

- Develop process improvements, supported by predictive performance models, in competing MEMS fabrication and packaging techniques.
- Perform six design and testing iterations of packaged MEMS.
- Demonstrate ability to fabricate low-cost, low-loss, long life MEMS switches meeting DoD requirements.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Sensors and Exploitation Systems, SGT-04	116.054	123.342	144.852	130.637	127.867	147.545	148.610	178.463

(U) Mission Description:

(U) The Sensors and Exploitation Systems project funds the development and demonstration of advanced sensors, and analytical and evaluative tools that take the products of those sensors to extract and compile useful, viable data. These efforts, in conjunction with those described in Projects SGT-01, SGT-02 and SGT-03, develop information needed to provide the warrior with situational awareness and precision target identification, with emphasis on the most stressing threats. The strategic goals of this project are to: develop key sensor technologies required to support battlefield dominance, including sensors that can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic exploitation of wide-area moderate (and high) resolution imagery; provide real-time, accurate Battle Damage Assessment (BDA); and provide robust, precise and reliable identification, precision fire control tracking and engagement of high value units, and critical moving targets. These goals are being addressed by the following programs: Advanced Exploitation Systems Technology, Network Centric Sensing and Engagement, Advanced Optical Sensor Technology, and Advanced Radar Sensor Technology.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Exploitation Systems Technology	25.332	39.300	52.004	47.998

(U) The Advanced Exploitation Systems Technology program will develop concepts, technology and tools to support rapid, high-performance autonomous and semi-autonomous interpretation and exploitation of sensor data products. These efforts develop techniques for the detection, classification and identification of military threats using advanced signal processing and machine vision approaches. They will also serve to process the raw sensor products from national, theater and organic surveillance and reconnaissance systems and tactical platform sensors. Complex target tracking and acquisition challenges under restrictive rules of engagement in difficult environments will also be addressed. The Advanced Exploitation Systems Technology Program will permit users to take full advantage of emerging sensor capabilities, and will address

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critical performance issues associated with timeliness, accuracy, error rates and interpretation workload. Initiative in this program include the following:

- The Frequency-Diverse Spatial/Spectral Sensor Exploitation initiative will develop and exploit emerging high-resolution multispectral, multipolarization, radio frequency, electro-optical (EO) and active optical sensors to provide a richer suite of exploitable features for rapid sensor exploitation. This technology will be used for mapping, terrain characterization, target detection and situational awareness. This effort will also explore applications appropriate for both medium and high altitude deployment. The Frequency-Diverse Spatial/Spectral Sensor Exploitation effort will develop technology to permit fusion, automated exploitation and visualization of combined products derived from these diverse classes of highly agile sensors. Sensors and processing techniques developed under this effort will be used to support wide-area detection, characterization and geolocation information for facilities, vehicle and dismounted targets in both tactical situation awareness and strategic indication and warning. These tools will support rapid mapping and terrain characterization support in near real time to support robotic and manned maneuver forces.

(U) Program Plans:
- Frequency-Diverse Spatial/Spectral Sensor Exploitation
  - -- Design, analyze and assess new concepts for RF, EO/IR and active optical frequency agile spatial/spectral/polarimetric sensor exploitation.
  - -- Perform phenomenological investigations to assess target signature stability, variability and seperability, and develop prototype exploitation tools to exploit these signatures.
  - -- Design, develop and evaluate brassboard sensor hardware and evaluate system performance under controlled environments.
  - -- Design, develop and evaluate form, fit and function sensor hardware, integrate onboard flight platform and evaluate performance over realistic targets and large clutter sets in flight tests.

- The National/Tactical Exploitation (NTEX) initiative serves to develop technologies that locate and identify enemy air defense units using multi-source imagery and data from both National reconnaissance systems and tactical sensor assets. Under a Memorandum of Agreement between DARPA and National Imagery and Mapping Agency (NIMA), the project will place researchers into facilities with access to real data and analysts managed by the "Geospatial Intelligence Advancement Testbed" (GIAT) project at NIMA. This will permit advanced sensor exploitation technologies to be developed in an environment where they can be rapidly assessed by operational analysts and evaluated using real world data. Building upon technologies developed under the DARPA Semi-Automated IMINT

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Processor (SAIP) Advanced Concept Technology Demonstration, the project will demonstrate increasing capability at modeling, detecting, and locating air defense targets and other surface threats (including those that have been denied, modified, or unmodeled).

(U) Program Plans:
- National/Tactical Exploitation (NTEX)
  - -- Demonstrate the ability to recognize components of specific air defense units using automated processing of national/tactical sensor data.
  - -- Demonstrate ability to model targets observed from a few sensor views, and then to locate and recognize those targets with an automated system in subsequent imagery.
  - -- Demonstrate a system to model denied and expedient targets from a few views, and then locate instances of those targets that would otherwise be missed by analysts, in a real-world practical problem.

- The Video Exploitation Technology (VET) initiative will develop technology for the automation of video exploitation. Specifically this program will support precision strike operations and urban surveillance. VET will also develop technology for the handoff of targets for identification and tracking, including wide area coverage Intelligence, Surveillance, and Reconnaissance (ISR) systems and local video surveillance platforms. This program will investigate techniques for precision target identification in video, including fingerprinting techniques and technology to permit reacquisition of previously seen vehicles. The development of techniques enabling video sensors to autonomously track people and targets through dense traffic will be featured, as well as technology to support target area searches for "no-strike" entities. These efforts will prevent unintentional collateral weapon effects. The VET program will develop exploitation technology to permit the recovery of 3D descriptions of targets and precision geolocation of targets observed by video sensors. This program will also explore innovative presentation and visualization concepts for video derived products, including immersive operator interaction with video. Using technologies derived from this effort, warfighters will be able to rapidly exploit data from ubiquitous visible and infrared video sensors, including airborne, ground, building perched, weapon video, emplaced sensors and hybrid systems. These systems will eliminate the one-camera, one-operator monitoring of video; permitting local video processing to prioritize data from multiple sensors for presentation to operators. This initiative will support interactive tracking for targeting and collateral damage avoidance and will provide a capability for autonomous and aided identification of targets from video data. These technologies will be integrated and demonstrated to assess the utility of video surveillance for a number of military missions, including counter-terrorism and military operations in urban areas.

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(U) Program Plans:
- Video Exploitation Technology (VET)
  - -- Develop techniques to automate the detection, classification, and tracking of mobile surface targets in visible and infrared motion imagery acquired by unmanned air vehicles.
  - -- Develop automated techniques to detect moving vehicles and people that could become unintended casualties in the vicinity of an impending air strike.
  - -- Demonstrate an integrated semi automated system to engage elusive surface targets using precision weapons guided by data derived from video sensors on airborne platforms.

- The objective of the Tactical Sensor Network Technologies (TSNT) initiative will be to build detection, tracking, identification, and pattern analysis capabilities that operate in all nodes (fixed or mobile) within a networked distributed multi-sensor system. Actual processing to be performed at each network node will depend on the sensors reporting to that node, the commanders subscribing to that node, and resource management performed. TSNT networked signal processing will exploit locality of sensing, but will leverage the self-forming adaptive network for processing. Algorithms will be natively aware of the limitations of the distributed sensor network and will adapt processing algorithms based on self-discovered network topology. These algorithms will also take into account power management constraints, communications bandwidth limitations and constraints found in the local environmental. This initiative will result in a truly distributed situation awareness, resilient to the failure of any individual node, but sufficiently consistent to serve as the basis for collaborative tactical planning.

(U) Program Plans:
- Tactical Sensor Network Technologies (TSNT)
  - -- Develop algorithms for distributed situation assessment at all nodes of a networked group of sensors.
  - -- Integrate and assess distributed system performance in large-scale simulation and more limited scale testing.
  - -- Demonstrate robustness of TSNT networked sensing under network and environmental stresses.
  - -- Incorporate tracking, target identification, and target assignment algorithms for fully distributed operation.

- The objective of the Exploitation of 3-D Data initiative (formerly known as Exploitation of Precision Data) will be to develop techniques that can rapidly exploit 3-D sensor data. This data is currently growing in availability from advanced sensors and can be used, for the purpose of precision target identification. The E3D Program seeks to demonstrate that the 3-D shape and structure of targets, together

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with 3-D information found within the context of the targets, can achieve much higher confidence in target identification than 2-D image-based methods. This effort has been divided into project modules. The Target Recognition module will provide a guide to the object recognition process, while the Target Acquisition module will perform target acquisition by searching a local 3-D volume for possible targets. The Modeling module will perform precision identification based on detailed shape analysis. The result of this program will be to deliver software tool sets that will be integrated into a collection platform equipped with a 3-D sensor.

(U) Program Plans:

- Exploitation of 3-D Data
  - -- Provide additional synthetic data and collected LADAR data for research and development modules, and acquire and refine 3-D models of potential target vehicles.
  - -- Develop tools to locate, classify, identify, and characterize the operational state of ground targets using data from 3-D sensors (e.g., LADAR) making use of structural models of candidate target geometries. The project aims to be able to deal with hundreds of candidate target types, and to perform precision recognition in the presence of articulation and obscuration.
  - -- Improve performance to real time processing.
  - -- Extend model-based vision technologies to classify, identify, and characterize the operational state of ground targets from other sources of 3-D sensor data.

- The Dynamic Tactical Targeting (DTT) initiative is developing new sensor control and data fusion technologies that will find, identify and track virtually every vehicle in a 30km x 30km area. This will aid in focusing weapon systems to target and destroy mobile, time sensitive targets (TSTs). The program is directed at challenging surveillance and reconnaissance problems and reducing the time to engage fleeting targets. DTT will design, build, and demonstrate a system capable of efficiently managing multi-sensor surveillance of large areas and large numbers of objects and, through fusion processes, extracting targets of high interest for hand-off to weapon systems. Furthermore, this initiative will provide the extracted targets, from the many moving objects in the battlespace, to precision engagement systems like AMSTE. The ultimate goal is to track and identify 10-25 ‘sensitive’ mobile targets in about a 1000 km^2 area containing approximately 1000 mobile objects. The Dynamic Tactical Targeting program will : (1) leverage existing National/Theater intelligence, surveillance and reconnaissance (ISR) processes for timely extraction of imagery, radar and signals intelligence data; (2) fuse data from Unattended Ground Sensors (UGS), Unmanned Air Vehicle (UAV) sensors and Human Intelligence (HUMINT) programs with Intelligence, Surveillance, and Reconnaissance (ISR) data (from all sources) to enable continuous estimation over time of target location, identity and activity; (3) dynamically task UGS and UAV sensors to fill ISR coverage gaps and provide relevant sensor observation in areas of tactical

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interest, and (4) close the loop between sensor management and fusion of the large volume of data produced by all these sensors to enable timely prosecution of critical fleeting targets. The product of this program will be a demonstration of real-time targeting of mobile TSTs in an operational environment.

(U) Program Plans:

- Dynamic Tactical Targeting (DTT)
  - Develop a process for closed loop control of ISR and in-situ sensors that provides wide area surveillance and scaleable focus of attention on selected areas of interest under direction of decision makers, to achieve rapid, continuous updates of time sensitive targets (TST) location, kinematics and identification.
  - Complete selection of appropriate UGS/UAV sensors to manage and fuse with national and theater ISR sensors.
  - Develop approaches to effectively and dynamically register all information products from UGS, UAV and ISR sensor data, HUMINT reports, and mapping sources to a common geo-spatial and temporal reference.
  - Develop new adaptive sensor management techniques for proactive management and placement of sensors and new data fusion techniques for dynamic exploitation of sensor data responsive to user information needs.
  - Construct a DTT testbed and conduct closed-loop system performance evaluations.

- The Real-Time Battle Damage Assessment (R/T BDA) initiative focused on developing and evaluating technology to permit all-weather, in-theater assessment of the effects of precision weapons on ground vehicle threats. R/T BDA exploited synthetic aperture radar sensors, including organic and theater sensors, which served to assess the effectiveness of munitions delivery and to provide feedback to attack systems during the mission. The program developed an algorithm and demonstrated the ability to automatically and reliably detect weapon impact for a wide variety of weapon/target pairings, using a technique that is called the "Target Impact Indicator." The algorithm has been installed in a central ground station where it can be used to process a variety of feeds from RF sensors. Demonstrations have been conducted with U-2 ASARS data and data obtained using the sensor that is slated for the Joint Strike Fighter and the F-22.

(U) Program Plans:

- Improve Target Impact Indicator radio frequency algorithmic techniques using data collected from instrumented live fire testing.
- Develop signature/weapons effectiveness assessment models based on impact indication and displacement.
- Perform integrated R/T SAR BDA experiments/demonstrations utilizing real time tasking, sensor exploitation and effects assessment in live fire environment.

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	FY 2002	FY 2003	FY 2004	FY 2005
Network Centric Sensing and Engagement	51.190	40.017	34.610	24.100

(U) The Network Centric Sensing and Engagement Program will develop concepts, technology and tools to support highly accurate situational awareness, rapid and precise targeting, and precision engagement through the exploitation of systems of networked sensors. Network-centric sensing looks at a group, constellation or field of sensors as a system, and leverages networked intercommunication to permit the sensor system as a whole to provide much higher performance than might be obtained from the individual sensors working in an uncoordinated fashion. This concept has application in advanced target detection, tracking, combat identification and target acquisition. Applications ranging from ground based fixed and mobile sensors to airborne multi-ship sensor systems are also covered. Exploiting the potential offered by network-centric sensing requires technology addressing multiple challenges. These technologies range from sensor-to-sensor communications and multi-sensor management, to sensor system gridlock and georegistation, real-time data fusion, advanced tracking and network-centric specific sensor operational modes. Initiatives in this program include the following:

- The Micro-Sensor Fields initiative will develop low-cost, lightweight micro-sensors for area reconnaissance, perimeter monitoring, and special/military operations on complex and urbanized terrain. Sensor technologies will emphasize low power, long life detection and discrimination technologies. Such technologies include ultra-wide band radar, micro-acoustics and nano-scale sensor technologies. This effort will develop robust techniques for rapid geolocation and data exfiltration from these sensors and will develop and demonstrate technology to permit exploitation, fusion and visualization of networks and fields of micro sensors. Micro-Sensor Fields will permit force protection with greatly reduced manning, monitoring of borders and critical CONUS sites, long duration covert monitoring of target sites (such as terrorist camps), support of deep strike engagement of mobile targets and support of comprehensive intelligence, surveillance, and reconnaissance for situational awareness. Micro-Sensor fields will enable persistent sensing of dismounted combatants in the toughest of environments, such as forested areas.

(U) Program Plans:
- Micro-Sensor Fields
  -- Develop breadboard ultra-wide band radar micro-sensor for dismount detection and tracking.
  -- Advance breadboard micro-sensor design to critical design review.

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-- Design receiver node to process micro-sensor detects into tracks and exfiltrate data.
-- Advance receiver and system design through preliminary design review.
-- Develop tracking algorithms to consolidate range only detects into contact tracks.
-- Fabricate targeted form factor micro-sensors.
-- Conduct ground demo with one receiver/processor and many micro-sensors.

- The Tactical Targeting Network Technologies (TTNT) initiative will develop, evaluate and demonstrate rapidly reconfigurable, affordable, robust, interoperable and evolvable communications technologies. Resulting technologies will be used to support airborne network-centric targeting. Specifically, TTNT will develop and demonstrate a tactical network that will be reconfigurable in fractions of a second, have wideband capacity (10+Mbit/s) on demand, have near zero (2ms) latency for high priority messages, be completely interoperable with Link 16, and be inexpensive to procure and to install. This program is addressing technical issues that include: physical waveforms and frequency allocations, fast security subsystems, distributed network management, and novel digital processing techniques to eliminate the need for centralized synchronization. TTNT is pursuing parallel data link design concepts. One concept exploits an omni antenna-based approach with a self-adaptive channel-sensing multiple user access protocol, implemented in conjunction with spread spectrum waveforms optimized for rapid carrier acquisition, combined with powerful turbocode error detection and correction. This physical layer will provide a well-integrated security architecture and a network architecture designed to exploit commercial-off-the-shelf technology wherever possible. A second concept is performing flight tests of a system built around the common data link family and utilizing a novel Ku band directional antenna that will offer the potential to demonstrate 20+Mbit/s connectivity between ISR assets, tactical aircraft and even small unmanned air vehicles.

(U) Program Plans:
- Tactical Targeting Network Technologies (TTNT)
  -- Complete simulation basis for Hardware-in-the-Loop (HWIL) testing.
  -- Complete system and sub-system risk reduction experiments.
  -- Complete brassboard design and fabrication.
  -- Complete brassboard TTNT flight experiments and demonstrations.

- The goal of the Affordable Moving Surface Target Engagement (AMSTE) initiative is to develop and demonstrate the technologies required to perform affordable, all-weather, precision negation of moving surface targets (both land and sea-based), from stand-off ranges

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using netted tactical and theater ground moving target indication (GMTI) sensors and weapons. The precise cueing from the netted GMTI sensors will allow for lower-cost weapons by reducing the complexity of precision munitions. Weapons system architectures have been developed and integrated to support a series of precision fire control bomb-drop field experiments and demonstrations. In-flight midcourse and terminal guidance to weapons has been implemented to demonstrate weapon system accuracy that is an order of magnitude better than current systems against moving targets. A number of critical technologies have been developed and integrated under AMSTE including unaided precision grid locking techniques, low-cost weapon data links, and advanced multi-platform tracking algorithms for both precision and long-duration, high-confidence track purity using moving target feature phenomenology for track maintenance. Additionally, battle management, command, control and communications (BM/C3) experiments have been pursued jointly with Service partners to enable rapid inclusion of AMSTE-enabled engagement capabilities into future operational architectures.

(U) Program Plans:

- Affordable Moving Surface Target Engagement (AMSTE)
  - Complete design, development and fabrication of the final field experiment system to support demonstration and evaluation of moving target engagement capabilities in an integrated operational environment.
  - Demonstrate a full AMSTE weapons delivery capability with advanced target track maintenance in live weapons drops with complex target dynamics

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Optical Sensor Technology	7.663	11.683	16.858	20.000

(U) The Advanced Optical Sensor Technology Program will develop advanced optical sensor technology to provide significant improvement in military sensor performance in situation awareness, surveillance, reconnaissance and targeting applications. These efforts are focused on exploiting emergent and novel optical sensing technology and phenomenology, including advancements in electro-optic, hyper spectral imaging, optical polarimetry and advanced three dimensional active optic sensing. Initiatives in this program include the following:

- The Standoff Precision ID in 3-D (SPI 3-D) initiative will develop and demonstrate the ability to provide high-resolution 3-D images at long ranges using an affordable sensor package. It will be capable of providing confirmatory ID at long range, and will have the ability to

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overcome weapons effects obscuration and penetrate foliage, camouflage and cloud layers. This sensor system will be capable of providing intensity, range and polarization for each pixel in the field of view. This program will conduct a series of ground, air and unmanned air vehicle demonstrations of standoff 3-D Ladar precision ID and track fusion techniques that provide for 1) rapid acquisition, 2) polarization exploitation, 3) intensity mapping, and 4) high range resolution to obtain precise identification of enemy ground moving targets. Demonstrations will employ existing commercial-off-the-shelf optics, focal plane arrays and gimbals, combined with a novel polarization to range mapping technique.

(U) Program Plans:
- Standoff Precision ID in 3-D (SPI 3-D)
  - Develop and test brassboard version of complete imaging system, including development of laser and Pockels' cell elements.
  - Determine accuracy and precision of ranging technique.
  - Develop flight engineered system.
  - Perform full-up ground tests from mountaintop test range.
  - Integrate and demonstrate system from manned aircraft against moving targets.
  - Integrate system into UAV and fully demonstrate system from UAV against variety of ground targets.

- The Synthetic Aperture Ladar for Tactical Imaging (SALTI) initiative will develop and demonstrate an airborne interferometric synthetic aperture laser radar (ladar) imager capable of producing high-resolution three-dimensional imagery at long ranges. The system will combine the long-range day/night access afforded by conventional synthetic aperture radar (SAR) with the interpretability of high-resolution optical imagery and the exploitability of three-dimensional (3-D) imagery. These capabilities will be provided within a tactical-sized package suitable for deployment on a long-range unmanned air vehicle such as the Global Hawk. The technical objective of the program is to provide a proof-of-concept for operation at tactically relevant high altitudes and at long ground ranges. A secondary goal of the program is to demonstrate single-view ground moving target indication (GMTI) with targeting quality absolute accuracy in range and cross-range when operating in a coherent, real-aperture mode.

(U) Program Plans:
- Synthetic Aperture Ladar for Tactical Imaging (SALTI)
  - Develop a laser transmitter containing an extremely stable local optical oscillator and other oscillators, modulators and power amplifiers necessary to create the time-dependent waveform and power required for synthetic aperture imaging.

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-- Develop a multi-element detector array including analog and digital electronics for coherently reading all elements of the array.
-- Integrate the detector array with an optical master oscillator to form a coherent receiver.
-- Develop image formation processing algorithms to coherently combine multiple laser pulse returns and to compensate for platform motion during the collection of these multiple pulses.
-- Demonstrate the collection of optical synthetic aperture imagery from an airborne platform and that produces high-resolution 2D and 3D image products.

- The goal of the Eyeball initiative is to develop and demonstrate novel concepts for precision target identification (ID) of moving and stationary tactical targets from standoff platforms by electro-optical sensors working in conjunction with air and space-based radar GMTI and Synthetic Aperture Radar (SAR) sensors. This program is motivated by the expectation that future radar assets will have the capability to perform target detection, location and tracking, and even some forms of target classification yet target ID performance will remain insufficient to allow targeting and allocation of attack assets due to radar and signature limitations. The Eyeball sensor will exploit the benefits of combining spatial, spectral and polarimetric signatures from sparse or filled apertures to enable real-time precision ID of critical tactical targets. In the concept of operations, a GMTI-SAR platform hands-off moving and stationary target location information to the Eyeball sensor. Eyeball serves to identify the target at standoff ranges and returns the target ID to the radar for track file association. Through episodic revisits, the GMTI-SAR platform maintains continuous track of the identified tactical target. The critical aspect of this program is to understand what is required in terms of combined spatial, spectral, and polarimetric signatures and resolution trades across the sensing domains to realize the required target ID performance.

(U) Program Plans:
- Eyeball
  -- Conduct and evaluate phenomenology, modeling and architecture/systems trades.
  -- Conduct ground-based experiments to validate and demonstrate technology.
  -- Design an airborne sensor system that could be used to demonstrate utility and concepts of operation.

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	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Radar Sensor Technology	31.869	32.342	41.380	38.539

(U) The Advanced Radar Sensor Technology program will develop advanced radar sensor technology to provide significant improvement in military sensor performance in situation awareness, surveillance, reconnaissance and targeting applications, focused particularly on surface targets and threats. These efforts are focused on exploiting emergent and novel radar sensing technology and phenomenology, including advancements in ultra-wide band, biostatics, UHF/VHF, polarimetric change detection, tomographic imaging, space-time adaptive processing and other advanced signal processing, advanced Ground Moving Target Indication (GMTI) techniques, and foliage and ground penetrating radar phenomenology. Efforts are focused on technologies appropriate for integration with current and emerging military platforms and are focused on the most stressing military radar sensor challenges, including operation against complex cluttered ground environments, against small and slow moving surface targets and in applications where camouflage, decoys and countermeasures must be overcome. Initiatives in this program include the following:

- The Wide Area All Terrain Change Indication Technologies (WATCH-IT) initiative will develop and demonstrate real-time VHF/UHF synthetic aperture radar (SAR) automatic change detection and discrimination technologies to provide rapid, robust detection of threat systems in the open, under camouflage and in foliated areas. Change detections will be examined by discrimination algorithms to determine if they have threat vehicle characteristics. These change indications will be use to cue on- or off-board high resolution sensors to perform target identification. WATCH-IT, which will operate from a platform such as a high altitude unmanned air vehicle (UAV), will demonstrate the ability to provide high area coverage rates with very few false alarms. This is a critical capability that currently does not exist. This program will also develop techniques to extract 3-D vehicle images from multiple-pass polarimetric SAR imagery to support confuser (i.e. decoys, relocated vehicles that are not of military significance) rejection and target classification / identification.

(U) Program Plans:

- Wide Area All Terrain Change Indication Technologies (WATCH-IT)
  - -- Perform data collections using low-frequency, high-resolution polarimetric SARs to quantify the robustness of wide area change detection to factors such as aircraft heading, depression angle, database aging, topography and terrain cover.
  - -- Assess alternative change detection algorithms to determine their robustness to data variations, their computational requirements and other such factors that will impact their performance and suitability for operating on a UAV.
  - -- Quantify probability of detection and false alarm rate for various operating conditions.

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-- Investigate methods to generate synthetic target signatures using software models or scaled frequency measurements.
-- Demonstrate WATCH-IT using the FOPEN SAR ATD system, with real-time on-board change detection and high-speed discrimination processing in the ground station.
-- Develop system specification for a fully integrated WATCH-IT system.
-- Develop, integrate, install and flight test the WATCH-IT on a manned or unmanned aircraft.

• The Foliage Penetration (FOPEN) Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER) (Formerly "Dynamic Tactical Sensing") initiative will support the future needs of FCS and the U.S. Army Objective Force by developing and demonstrating a FOPEN Ground Moving Target Indication (GMTI) radar. This radar will provide persistent, long-term detection and tracking of enemy combat vehicles and dismounted troops moving in open and forested areas of the battlefield, thus giving U.S. forces a much higher level of information dominance and allowing Objective Force commanders to operate with confidence in forested areas. FORESTER will also provide the ability to detect low-flying aircraft such as helicopters and ultra-lights, and will produce synthetic aperture radar images that can support terrain delimitation, road identification and target tracking in wooded areas. The FORESTER program will develop a UHF-band FOPEN GMTI radar to be deployed on rotary wing platforms such as the A160 unmanned helicopter. The radar will achieve calm-weather detection ranges in excess of 30 km against dismounted troops moving with radial velocities of 0.75 m/sec or higher in forested areas from a hovering platform under calm wind conditions. Adaptive antenna processing and innovative radar waveforms will allow FORESTER to overcome radio frequency interference and electronic countermeasures in hostile electromagnetic environments.

(U) Program Plans:

- Foliage Penetration (FOPEN) Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER)
  -- Develop and demonstrate the ability to detect slowly moving ground targets in foliage using rotorcraft mounted GMTI radars through measurements, simulations and analyses.
  -- Design, assess, and evaluate a brassboard FORESTER hardware system.
  -- Design, assess, and evaluate a form-fit and function FORESTER hardware system for rotorcraft installation and conduct end-to-end system performance tests that include all aircraft effects under static and dynamic conditions.
  -- Conduct airborne flight-testing and demonstrate performance with the fully integrated FORESTER/aircraft system. User evaluations will be performed to develop the system CONOPS and to demonstrate FORESTER's capabilities to the Warfighter.

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- The Organic Ground Moving Target Identification (GMTI) Radar (OGR) initiative investigated the technologies required to enable a low-cost capability for the ground-based detection and tracking of moving vehicles and personnel through foliage. The goal was to detect vehicles at ranges of 5-10 km and personnel at ranges of 1-3 km with low false alarm rates. One concept was based on the use of separated transmitters and receivers that are designed for low cost and portability. To ensure adequate foliage penetration, the system was designed to operate in the VHF-UHF frequency regime. A second concept was to deploy small L-Band monostatic radars at high altitude (e.g. 500-1500 m) and gain foliage penetration through steep look-down angles, penetration of tree lines and optimal location of the radars (e.g. looking down roads). An L-band GMTI radar using a circular array was also assessed. This program completed in FY 2002.

- The Knowledge Aided Sensor Signal Processing and Expert Reasoning (KASSPER) initiative will radically alter the fundamental “front-end” signal processing architectures within the radar discipline through the real-time integration of dynamic environmental knowledge to dramatically improve clutter and interference rejection and significantly enhance sensor products. All conventional and advanced radio frequency sensors that employ any form of adaptive signal processing estimate the background interference using the same data that is used for target detection. Additionally, it is assumed that the background interference over the region used to perform the estimation is stationary and homogeneous. However, numerous sensors have demonstrated, in real environments around the world, that this assumption is not valid. This problem manifests itself in increased false alarms, decreased target detections, and substantially degraded minimal detectable velocities in Ground Moving Target Identification (GMTI) systems. KASSPER will leverage the advent of detailed databases and high fidelity models to address inhomogeneities and non-stationarity at the very front end of adaptive signalprocessing systems. Key technologies to be developed include advanced algorithms and high-performance computing architectures capable of performing very memory intensive adaptive signal processing. Extensive data collections will be carried out and the program will culminate in a real-time demonstration of its processing gains.

(U) Program Plans:

- Knowledge Aided Sensor Signal Processing and Expert Reasoning (KASSPER)
  - Develop advanced expert-reasoning algorithms using real and simulated data sets in non-real-time and real-time modes.
  - Develop real-time, high-dimensionality KASSPER software.
  - Conduct off-line KASSPER Constant False Alarm Rate & Radar (CFAR) demonstration.
  - Conduct KASSPER workshops with challenge data sets for signal processing community.
  - Define high performance embedded computing architecture to enable rapid memory access; design, build, test, and demonstrate.

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-- Collect highly instrumented monostatic data set for distribution and real-time demonstration.
-- Demonstrate KASSPER performance gains in real-time processing environment using real data sets.

- The goal of the Counter Camouflage, Concealment and Deception (CC&D) initiative is to significantly enhance the military's capability to detect and track targets hidden under foliage and camouflage. Specific goals include the validation of Foliage Penetration (FOPEN) target detection and false alarm rejection capability. This synthetic aperture radar (SAR), has been developed for demonstration on a manned RC-12 aircraft, and provides inputs via tactical data links for ground image exploitation. A Ground Control and Display Subsystem have been developed to provide real-time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing and a Common Imagery Ground/Surface System-compliant exploitation interface. Advanced change detection and three-dimensional imaging algorithms are under development. Techniques have also been developed to characterize the terrain cover and the bald earth topography in support of Future Combat Systems.

(U) Program Plans:

- Counter Camouflage, Concealment and Deception (CC&D)
  -- Conduct a FOPEN SAR ACTD in FY03 – 06 under SOUTHCOM sponsorship to demonstrate the military utility of FOPEN technologies.
  -- Continue developing techniques for false alarm and clutter mitigation.
  -- Collect data to support terrain characterization under foliage.
  -- Support the Air Force's Targets Under Trees (TUT) initiative.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	36.141	32.224	13.898	0.000	0.000	0.000	0.000	0.000
Advanced Ship-Sensor Systems, MRN-02	36.141	32.224	13.898	0.000	0.000	0.000	0.000	0.000

(U) <u>Mission Description:</u>

(U) The objective of the Marine Technology program is to identify, develop and rapidly mature critical advanced technologies and system concepts for maritime applications that support the following goals: 1) maintenance of U.S. naval force access to the littoral by countering the threat created by the worldwide spread of increasingly sophisticated technology; 2) enhancement of the ability of U.S. naval forces to interrogate and dominate the maritime battlespace, particularly in the littoral arena; 3) advances in the ability of U.S. naval assets to conduct operations as a seamlessly networked and integrated theater level force; and 4) improved power projection capabilities of U.S. naval forces, particularly with respect to their ability to influence the land battle. Proliferating threats such as modern cruise missile technology, commercially available overhead surveillance, advanced undersea mine capabilities, and modern, quiet diesel/electric submarines, pose major challenges for operations in the restricted water, near-shore regimes that are of growing importance to U.S. strategic considerations, necessitating continued development of increasingly affordable far-term solutions for enhancing the operating capability and survivability margins of U.S. naval forces in the littoral. This program element funds the Advanced Ship-Sensor Systems project (MRN-02), comprised of the following programs: the Robust Passive Sonar (RPS) program; the Loki Systems Development Program; the Undersea Littoral Warfare thrust which includes the Piranha effort, the Long Range Mine Detection effort, and the Smart Actuators and Marine Projects Demonstration effort; and the Buoyant Cable Array Antenna (BCAA) program. This project draws to an end in FY 2004. Programs traditionally budgeted in this project will instead be budgeted in PE 0603766E, Project NET-02 to better reflect today's emphasis on network centric warfare.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Marine Technology PE 0603763E, R-1 #47

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Robust Passive Sonar (RPS)	19.315	16.600	9.242	0.000

(U) The Robust Passive Sonar (RPS) program is developing innovative, adaptive signal processing algorithms for passive submarine and surface ship towed arrays that suppress the acoustic interference generated by surface shipping and increase the detectability of threat submarines. At the lower acoustic frequencies, shipping interference represents the primary noise background limiting the performance of existing sonar systems in littoral areas. Precise notching of shipping interference could result in net system performance gains of 10-20 dB, and the algorithms and array geometries used to accomplish this will dictate future tactical sonar designs. The program has successfully collected high quality, mobile, multi-line, towed array acoustic and ancillary data and utilized this data to develop and assess signal processing architectures and algorithms. Initial performance assessments indicate significant suppression of acoustic interference is achievable.

(U) Program Plans:

- Complete end-to-end prototype signal processing architecture with advanced surface shipping interference rejection algorithms and demonstrate extended target detection.
- Conduct non real-time system performance using RPS sea-test data.
- Initiate real-time processing architecture and algorithms development.
- Demonstrate real-time end-to-end prototype signal processing system at-sea.
- Initiate planning of real-time at-sea system demonstration.
- Continue system trade studies for alternative acoustic aperture concepts.

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	FY 2002	FY 2003	FY 2004	FY 2005
Loki Program	4.809	9.570	0.000	0.000

(U) The Loki program is developing technologies to enable a revolutionary "fighter-like" submersible to counter the asymmetric threat posed by diesel submarines and other forces operating in the littorals. Loki has two major technology component elements: The Vortex Combustor propulsion technology and the Loki Systems technology development efforts. Objectives include: 1) the development of an energy-dense air independent underwater power source as a potential propulsion system for an underwater fighter, and 2) the investigation and development of detailed concepts of supporting systems and potential hull forms necessary for the operational viability of a future underwater fighter. Such an underwater vehicle would have the potential to revolutionize military and commercial undersea operations and the operational agility of maritime operations in the littoral. The results of these efforts will include: (1) the fabrication and testing of a small-scale vortex combustor power system, and (2) detailed concept and technical feasibility studies on supporting systems such as piloting, navigation, and collision avoidance systems as well as useful hull forms for conceptual high speed submersibles. These efforts transition to PE 0603766E, Project NET-02 beginning in FY 2004 to better incorporate them with other network centric warfighting capabilities.

(U) Program Plans:

- Vortex Combustor (VC).
  - Conduct analysis and performance evaluation.
  - Fabricate additional test units.
  - Develop start and restart system.
  - Develop control system.

- Loki Systems Development.
  - Conduct concept of operations and military utility studies.
  - Initiate system structural materials explorations.
    - Hydrodynamic performance modeling.
    - System structural materials explorations.
    - Advanced personnel pod design.

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-- Initiate sensor guidance and control design studies.
-- Simulation modeling of high agility, full speed control authority.
-- Concept development of autonomous control systems.

	FY 2002	FY 2003	FY 2004	FY 2005
Undersea Littoral Warfare (ULW)	3.268	6.054	4.656	0.000

(U) The ULW program is developing approaches to undersea warfare that will revolutionize the ability to classify and identify underwater objects such as mines. The ULW program seeks to provide the Navy with technologies that will allow U.S. submarines to dominate in the littoral battlespace and transform the submarine's role in littoral warfare. In doing so, the program will investigate: technologies and demonstrations for locating and tracking maritime targets of interest; innovative networking; sensor and array technologies; technologies and demonstrations enabling unique weapons or payload concepts for potential deployment on submarines and other undersea vehicles; and technologies for buried mine identification and classification in the littoral. The following specific efforts are included.

(U) The Piranha effort will enable submarines to engage elusive maneuvering land and sea targets by exploiting emerging battlefield Intelligence, Surveillance and Reconnaissance (ISR) sensors, wideband networked communications, real-time exploitation targeting algorithms, and existing/planned submarine strike weapon systems. Submarines are a key and enduring element of the current and future naval force with unique stealth, mobility, and endurance characteristics and are often the first strike unit on scene. Submarines have proven to be relatively immune to advances in weapons and information technology that increasingly put U.S. surface/air forces at risk and their importance as an effective forward deployed strike asset is likely to continue to increase. This effort will develop key technologies that enable attack and cruise missile submarines to play a wider role in responding to time-urgent maneuvering targets from a forward-deployed position. The Piranha effort will focus on the following key technology areas that enable submarine strike missions in the littorals: continuous asymmetric connectivity to intelligence, sensors, weapons and other vessels while at depth; ISR sensor data exploitation for targeting (sensor-to-weapon handoff); advanced offboard sensor concepts to include swarms of mini unmanned underwater vehicles (UUVs) for sensing sea targets; mobile underwater Global Positioning System (GPS) concepts; undersea networked sensor communications; and low latency target detection, identification, and geo-referencing. The effort will pursue a progression of more realistic demonstrations, culminating in closed loop submarine engagement of moving ground surface vehicles and sea targets. This effort will transition to PE 0603766E, Project NET-02 in FY 2004 to better reflect the inherent network centric emphasis.

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(U) Under the Long Range Mine Detection effort DARPA is investigating the potential capabilities of technologies for detection and discrimination of mines at long ranges. These technologies include: (1) acoustic projectors that could perform as compact and powerful low frequency sources, (2) the development of algorithms that enable adequate resolution and signal excess at long-range, (3) the development of signal processing algorithms for the detection, false alarm mitigation, and clutter rejection, and (4) the development of technologies associated with real-time processing of this data. This effort will also be coordinated with the Office of Naval Research (ONR) and the U.S. Navy's Mine and Undersea Warfare offices. Each of these other offices assists in this program to develop criteria and technologies that advance the state of mine detection in littoral regions.

(U) The Smart Actuators and Marine ProjectS demonstratiON (SAMPSON) effort is a systems level demonstration of the application of Smart Materials/Structures to enable vehicles to change the way they operate and take on new missions. By employing this technology aircraft will achieve dramatically improved range, maneuverability and enhanced survivability and marine vehicle turbo-machinery will operate with improved performance characteristics. SAMPSON core technology efforts have produced several new concepts and designs for high force, large displacement, low rate actuation using both shape memory alloys (SMAs) and piezoceramics. Preliminary designs for a high force and high stroke SMA tendon actuator that will considerably exceed the force/stroke capabilities of any SMA actuator known to date have been completed.

(U) Program Plans:

- Piranha.
  - Design and prototype off-board antenna.
  - Demonstrate endurance of underwater fiber optic link between antenna and moving platform.
  - Investigate submarine-deployed surface ISR sensor concepts.
  - Demonstrate wideband asymmetric communications at depth.
  - Develop and demonstrate real-time submarine ISR data processing and targeting algorithms.
  - Demonstrate closed-loop submarine engagement of a moving ground surface vehicle using non-organic sensors.
  - Develop and demonstrate submarine-deployed ISR sensor.
  - Demonstrate closed-loop submarine engagement of a moving ground surface vehicle incorporating submarine-deployed sensor inputs.

- Long Range Mine Detection.
  - Proof of Concept Phase: demonstrate the feasibility of long-range mine discrimination.
    - Perform at-sea data collections.

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-- Develop signal-processing algorithms based on data.
-- Develop detailed models to enable future engineering development decisions.

- Smart Actuator and Marine ProjectS demonstratiON (SAMPSON).
  - Demonstrate Smart Structures benefits by maximizing the integration of actuators with structures.
  - Develop smart materials based actuator performance.
  - Explore actuator performance.
  - Conduct SAMPSON performance testing and demonstration.
  - Model recent advances in low cost nanofluids shown to reduce friction.
  - Design, fabricate and test novel parasitic energy devices and associated supporting concepts/technologies.

	FY 2002	FY 2003	FY 2004	FY 2005
Buoyant Cable Array Antenna (BCAA)	8.749	0.000	0.000	0.000

(U) The Buoyant Cable Array Antenna (BCAA) program developed an antenna capable of supporting full duplex (transmit and receive) connectivity for voice and data with communications satellites while floating on the ocean's surface. Towed behind a submarine, this capability enables high quality, high data-rate connectivity with other military assets, even while operating at speed and depth. Supporting technologies included photonic signal and power links, enhanced antenna loading materials, processing algorithms for blind adaptive array calibration and wash over mitigation, advanced communications protocols and signature minimization techniques. This program transitioned to the Navy at the end of FY 2002.

(U) Program Plans:
- Completed at-sea technical validation of BCAA prototype.
- Transitioned BCAA technology to Navy for follow-on development.

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

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	36.497	33.000	47.638	74.367
Current President's Budget	36.141	32.224	13.898	0.000
Total Adjustments	-0.356	-0.776	-33.740	-74.367
Congressional program reductions	0.000	-0.776		
Congressional increases	0.000	0.000		
Reprogrammings	-0.356	0.000		
SBIR/STTR transfer	0.000	0.000		

(U) Change Summary Explanation:

FY 2002	Decrease reflects below threshold reprogramming.
FY 2003	Decrease reflects Congressional undistributed reductions.
FY 2004 – FY 2005	Decrease reflects transfer of programs to PE 0603766E, Project NET-02.

(U) Other Program Funding Summary Cost:

Buoyant Cable Array Antenna (BCAA)	FY 2002	FY 2003	FY 2004	FY 2005
PE 0604503N, Submarine Integrated Antenna Systems/X0742	1.705	2.723	0.000	0.000

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, R-1 #48			
COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	153.017	165.963	82.387	15.433	0.000	0.000	0.000	0.000
Rapid Strike Force Technology LNW-01	14.444	9.261	0.819	0.721	0.000	0.000	0.000	0.000
Small Unit Operations LNW-02	25.023	31.841	18.578	0.000	0.000	0.000	0.000	0.000
Future Combat Systems LNW-03	113.550	124.861	62.990	14.712	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. Three broad efforts are being pursued in support of this objective: Rapid Strike Force Technology, Small Unit Operations and Future Combat Systems.

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces. This project is developing technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance as well as effective and adaptive weaponry, which are important aspects of an early-entry capability. The project consists of: the Reconnaissance, Surveillance and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Metal Storm (MS), Mach 5/50 Technology Development, and the Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration program. These programs are closely coordinated with the U.S. Army, Navy and Marine Corps, and with DARPA's Small Unit Operations (LNW-02) project.

(U) The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

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(U) The U.S. Military requires flexible, effective and efficient multi-mission forces capable of projecting overwhelming military power worldwide. This force must ultimately provide our national leaders with increased options when responding to potential crises and conflicts. To satisfy this requirement, the joint Army/DARPA Future Combat Systems (FCS) program was developed to provide enhancements in land force lethality, protection, mobility, deployability, sustainability, and command and control capabilities.

(U) **Program Change Summary:** *(In Millions)*	**FY 2002**	**FY 2003**	**FY 2004**	**FY2005**
Previous President's Budget	153.067	162.100	121.407	73.561
Current President's Budget	153.017	165.963	82.387	15.433
Total Adjustments	-0.050	3.863	-39.020	-58.128
Congressional program reductions	0.000	-4.137		
Congressional increases	0.000	8.000		
Reprogrammings	-0.050	0.000		
SBIR/STTR transfer	0.000	0.000		

(U) **Change Summary Explanation:**

FY 2002	Decrease reflects a below threshold reprogramming.
FY 2003	Increase reflects $8 million transfer from DERF for the Wolfpack program offset by congressional undistributed reductions.
FY 2004 - 2005	Decreases reflect realignment of Projects LNW-01 and LNW-02 funding to PE 0603766E, Project NET-01.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA3 Advanced Technology Development	Land Warfare Technology PE 0603764E, Project LNW-01

COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Rapid Strike Force Technology, LNW-01	14.444	9.261	0.819	0.721	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces. This project is developing technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance as well as effective and adaptive weaponry, which are important aspects of an early-entry capability. The project consists of: the Reconnaissance, Surveillance and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Metal Storm (MS), Mach 5/50 Technology Development, and the Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration program. These programs are closely coordinated with the U.S. Army, Navy and Marine Corps, and with DARPA's Small Unit Operations (LNW-02) project. This project draws to an end in FY 2005. Programs traditionally budgeted in this project will be reflected in a new program element 0603766E, project NET-01, to better reflect today's emphasis on network centric warfare.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Reconnaissance, Surveillance and Targeting Vehicle (RST-V)	5.274	3.049	0.000	0.000

(U) The Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program is designing, developing, testing/demonstrating and transitioning to the Services four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle incorporates technological advancements in the areas of integrated survivability techniques and advanced suspension. The vehicle also hosts integrated precision geolocation, communication and Reconnaissance, Surveillance and Targeting sensor subsystems. The RST-V platform provides a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical reconnaissance teams, fire support coordinators and special reconnaissance forces. Hardware and lessons learned from this program directly support the Marine Corps-Navy Extending the Littoral Battlespace (ELB) Advanced Concept Technology Demonstration

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(ACTD) as well as address joint U.S. Marine Corps – Special Operations Command (USMC-SOCOM) requirements for the Internally Transportable Vehicle/Light Strike Vehicle (ITV/LSV), Tactical Vehicle, Reconnaissance, Surveillance, Targeting and Acquisition (TV-RSTA) program and High Mobility Multi-purpose Wheeled Vehicle (HMMWV) upgrades. The Marine Corps will develop vehicle concepts and chassis, integrate the DARPA developed components and conduct vehicle performance tests (PE 0603640M) through participation in scheduled Advanced Warfighting Experiments (AWEs) and ACTDs (e.g., Capable Warrior).

(U) Program Plans:

- Continue enhancing high voltage battery power conversion, refurbishing battery packs and upgrading system control equipment.
- Rollout vehicles 3 and 4.
- Conduct Technical Performance Measure Verification.
- Conduct users' evaluation and assessment with potential USSOCOM/USMC/US Army customers.
- Deliver vehicles 1, 2, 3 and 4.
- Deliver final report.

	FY 2002	FY 2003	FY 2004	FY 2005
Tactical Mobile Robotics (TMR)	3.392	0.993	0.000	0.000

(U) The Tactical Mobile Robotics (TMR) program developed mobile robotic technologies to enable land forces to dominate the battlespace through employment of mobile semi-autonomous robot teams performing challenging missions in complex environments (dynamic urban areas, rugged terrain with high obstacle clutter, etc.). TMR has provided DoD organizations with a team of semi-intelligent, cooperating robot prototype platforms carrying a variety of integrated mission payloads required to conduct activities in risk intensive or inaccessible areas. Operational emphasis was on urban environments and denied areas. Specific robot technologies that were advanced include: machine perception, autonomous operation and advanced locomotion for complex obstacle negotiation. Perception capabilities included: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20Hz; and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90 percent accuracy. Autonomous operation capabilities included: (a) coordination of the tactical behavior of a multi-robot team with significant command cycle reduction; and (b) traversal of rugged/complex terrain using one command per 100 meters of travel. TMR prototypes were used during Operation Enduring Freedom

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for cave clearing and on numerous other activities including explosive ordinance disposal and recovery operations at the World Trade Center immediately following the September 11th attacks. TMR prototypes and research artifacts have been transitioned to the DoD Joint Robotic Program where they are being utilized to support additional research on robots.

(U) Program Plans:
- Completed final prototype modifications.
- Transitioned to military departments.

	FY 2002	FY 2003	FY 2004	FY 2005
Metal Storm (MS)	2.801	0.000	0.000	0.000

(U) The Metal Storm program demonstrated a revolutionary technique for firing tactically relevant projectiles at very high rates without the need for internal moving parts. The elimination of moving parts from the system significantly reduced production, operation and support costs, and decreased the level of maintenance required in the field. This effort demonstrated : 1) electronic sequential firing of three or more projectiles from a *single* barrel with the shortest possible time interval between rounds; 2) projectile penetration 25.4 mm of rolled homogenous armor at 1,000 meters; and 3) maximum vertical spread of 1 1/2 minute of angle at 300 and 600 meters. Studies were conducted to explore the feasibility and applicability of Metal Strom technology to other weapon systems, including vehicle self-defense, anti-personnel landmine replacement, and a naval self-defense system. As a result of data gathered under this program, a more promising endeavor has been undertaken in the Mach 5/50 Technology Development. Therefore, this program ends in FY 2002 and transitions to the Mach 5/50 Technology Development program.

(U) Program Plans:
- Conducted vented bomb tests.
- Conducted preliminary smooth bore test firings with U.S. contractor and Australian government partner.
- Performed a series of rifled bore proof-of-principle test firings with performance increasing to the minimum time interval between rounds and 1200 m/s muzzle velocity.
- Demonstrated a preliminary reloading concept.

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- Designed and simulated high performance, multi-barrel systems for launching 40-50 millimeter supersonic projectiles.
- Conducted testing and assessment of critical system components.

	FY 2002	FY 2003	FY 2004	FY 2005
Mach 5/50 Technology Development	2.977	1.323	0.819	0.721

(U) Early Metal Storm tasks demonstrated revolutionary weapon concepts for firing small caliber projectiles at very high rates without the need for internal moving parts. The continuing Mach 5/50 tasks extend the concepts and technologies for leap-ahead performance in tactically relevant, lightweight, medium caliber direct fire weapons. The medium caliber projectiles (50 millimeter bore) will have a minimum muzzle velocity of 1,600 meters per second (~ Mach 5) at 600 rounds per minute or greater. Mach 5/50 technology development will provide multiple services with a low-cost, reliable enabling technology to support a wide range of current/future applications including extended range combat vehicle firepower and lethality, full-spectrum future combat vehicle lethality for active protection systems, high engagement rate naval air defense, critical fixed site defense and improved aircraft self-defense. Portions of the technology development will be conducted under an agreement with the Australian Defence Science and Technology Office.

(U) Program Plans:

- Develop medium caliber concepts, detailed performance simulations and technical analyses.
- Fabricate and test critical technology subsystems.
- Complete integration of pre-prototype components and evaluate against simulation-based interim performance parameters.
- Critical design review and complete fabrication of full-function prototype.
- Complete system test and evaluation of full function prototype and validate simulations.
- Conduct firing demonstration and deliver final report.
- Transition hardware and data packages to DoD laboratories for Service-specific engineering and platform integration.

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	FY 2002	FY 2003	FY 2004	FY 2005
Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD)	0.000	3.896	0.000	0.000

(U) The primary goal of the MAV ACTD program is to further develop and integrate MAV technologies into militarily useful and affordable backpackable systems suitable for dismounted soldier, marine, and special forces missions. It will focus on the development of MAVs to accomplish unique military missions, particularly with regard to flight operations in restricted environments. The objective of the MAV ACTD is to demonstrate a backpackable, affordable, easy-to-operate, and responsive reconnaissance and surveillance system. The system will provide the small unit with militarily useful, real-time combat information of difficult to observe and/or distant areas or objects. The system will also be employable in a variety of warfighting environments. For example, it will be beneficial in complex topologies (i.e., mountainous terrain with caves), heavily forested areas/dense foliage/triple canopy jungle, confined spaces (often internal to buildings) and high concentrations of civilians (where it may be critical to determine the neutral or hostile intent of a crowd). The initial MAV technology development program focused on the technologies and components required to enable flight at small scales, including flight control, power and propulsion, navigation and communications. The MAV ACTD program will also leverage other DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectromechanical Systems (MEMS), advanced sensors, advanced electronic packaging technologies, and lightweight, efficient high-density power sources. This program will be funded from PE 0603766E, Project NET-01 in FY 2004 and FY 2005.

(U) Program Plans:

– Demonstrate electric MAV in military operations in urban terrain exercises and conduct experiments with troops in field trials.
– Evaluate lessons learned and design of diesel MAV.
– Conduct further experiments with troops in the field to complete detailed design of hybrid MAV.
– Conduct experimentation of hybrid MAV; evaluate lessons learned; provide optimum MAV for evaluation.
– Conduct experimentation of optimum MAV and complete final military evaluation.

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(U) Other Program Funding Summary Cost:

Reconnaissance, Surveillance and Targeting Vehicle (RST-V)	FY 2002	FY 2003	FY 2004	FY 2005
PE 0603640M, Marine Corps Advanced Technology Demonstration	1.982	0.000	0.000	0.000
PE 0602131M, Marine Corps Future Naval Capabilities	1.000	0.000	0.000	0.000

Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD)	FY 2002	FY 2003	FY 2004	FY 2005
PE 0603001A, Army	10.000	0.000	0.000	0.000
PE 0603750D, OSD	1.000	4.400	*	*

*funded in concert with the MAV ACTD effort in NET-01.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Small Unit Operations LNW-02	25.023	31.841	18.578	0.000	0.000	0.000	0.000	0.000

(U) Mission Description:

(U) The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

(U) The objective of the Small Unit Operations Project is to develop critical technologies that will enable small dismounted forces to effectively fight anywhere, anytime. The technology needs are: semi-automated maneuver and strike/fire planning and re-planning that can be employed by commanders who are physically separated but need to be virtually collocated; automated aggregation and mining of information sources to provide a "bubble" of awareness over each warrior and team describing the relevant situation; accurate geographic position estimation, other than GPS, which works in all environments; and radio links and self-forming ad hoc networked communications that "glue" the components together, operate in any environment, are covert and resistant to interference. In addition, these technologies must not significantly increase the dismounted force's mass and power burden. The programs that make up this project include Wolfpack, the Situational Awareness System (SAS), Tactical Sensors, Optical Tags, and Advanced Sensing Technologies. This project draws to an end in FY 2005 and programs traditionally budgeted in this project will instead be located in Program Element 0603766E, Project NET-01, to better reflect today's emphasis on network centric warfare.

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(U) <u>Program Accomplishments/Planned Programs:</u>

	FY 2002	FY 2003	FY 2004	FY 2005
Wolfpack	11.195	25.541	16.097	0.000

(U) The Wolfpack program will develop technologies that would enable the U.S. to deny the enemy use of radio communications and radars throughout the battlespace. The networked system will be comprised of autonomous, ground-based monitors/jammers that are cooperatively linked to avoid disruption of friendly military and protected commercial radio communications and radars. The specific technologies to be developed include: (1) high efficiency sub-resonant antennas, (2) networking algorithms to allow coordinated access to the spectrum by communicators, jammers and SIGINT systems, (3) methods to easily deploy the systems in RF advantaged sites, and (4) algorithms to rapidly and autonomously detect, classify, identify and jam target signals with low power electronics.

(U) In FY 2003, additional funding was added from the Defense Emergency Response Fund for the development of an accelerated Wolfpack capability. These funds will be used to enable early development of technologies that could lead to a rudimentary Wolfpack-like system. Potentially used as a Distributive Suppression of Enemy Air Defense (DSEAD) asset, these rudimentary, close proximity WolfPack systems could permit non-lethal disruption of enemy radar systems, including possible terrorist reuse of civilian platforms.

(U) Program Plans:

- Wolfpack:
  - Develop enabling technologies.
  - Complete system design and performance analysis.
  - Verify low duty cycle, low power jamming techniques with benchtop experiments.
  - Construct and lab test brassboard-jamming subsystems.
  - Conduct limited lab tests using brassboard equipment to attack several legacy type communication systems.
  - Design, develop, and demonstrate via simulation and field tests the specific technologies developed.

- Wolfpack Accelerated Program
  - Mature enabling technologies for potential development of rudimentary Wolfpack-capable system.

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	FY 2002	FY 2003	FY 2004	FY 2005
Situational Awareness System (SAS)	6.867	1.500	0.000	0.000

(U) The Situational Awareness System (SAS) will integrate a variety of communications, navigation and data processing technologies into an eventual 1 kg module (plus 0.5 kg per day for the power source) worn by the individual warrior. The radio frequency module will be interoperable with the Army Land Warrior equipment and provide much greater functionality. The warrior module will provide the communications and computing power to fully interconnect the dismounted force and enable situation awareness information to be distributed, as well as support continuous planning and combat execution. This program will investigate the critical SAS performance parameters with in-depth experiments. It will provide user-centered design input for developers and provide an independent assessment of the SAS design. The experiments will be focused to evaluate the sensor employment, validate network robustness and reliability, and conduct a scenario-focused evaluation of geolocation and navigation requirements in urban, forested and mountainous terrain. Specialized tools will be developed to generate scenario-synchronized data for development and evaluation of the SAS functions. The program will coordinate the use of testing infrastructure to conduct evaluations and assessment and will employ a combination of military and technical subject matter experts, computer modeling and simulation tools, and laboratory and field exercises to provide independent validation of the SAS functionality.

(U) Program Plans:

- Completed prototypes.
- Developed training materials and conducted soldier training for field demonstration.
- Conducted field demonstration to verify communications performance in urban, forested, and mountainous terrain when operated by warfighters.
- Demonstrated the use of multiple organic sensors being operated by battalion and below warfighters.
- Transitioned to the Army, Marine Corps and U.S. Special Operations Command (USSOCOM).

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	FY 2002	FY 2003	FY 2004	FY 2005
Tactical Sensors	3.646	1.800	0.000	0.000

(U) The Tactical Sensors program is developing a new generation of unattended ground sensors, planning tools, deployment mechanisms, and command and control components that will provide the warfighter a capability to remotely and cost effectively detect, track, classify and identify mobile tactical targets. This lightweight, long-life system provides the warfighter with unmanned, high confidence reconnaissance, targeting, and surveillance, for integrated force protection and non-line of sight remote sensing in denied or life-threatening areas of interest. An open system architecture reduces logistic costs and anticipates future integration of advanced sensor modalities by service materiel developers via preplanned product improvements. Through integration with current and developmental C2 systems, information provided by these systems can be fused with other assets to enhance the aggregate situational awareness of U.S. forces. The emphasis in the final year will be to identify transition opportunities within the Air Force, Marine Corp, and Army whose employment requirements span fixed wing, rotary wing, ground vehicle, weapon-based or hand emplacement methods.

(U) Program Plans:
- Complete development and field-test unattended sensor and gateway nodes for detection, classification and tracking of mobile tactical targets such as missile launchers, armored personnel carriers, logistics vehicles, mobile cruise missile launchers, tanks and light vehicles.
- Develop planning and monitoring tools for the warfighters, including emplacement decision aids using 3D topography, foliage, weather, trafficability and target information. Provide for early warfighter input, test, evaluation and redesign.
- Integrate and demonstrate a fielded deep deployment system followed by node self-erection and autonomous cluster organization, reporting and geo-location.
- Interface to operational command and control networks.
- Demonstrate 70 percent probability of detection at 3,000 meters, 20 meters RMS tracking errors at 500 meters and greater than 90 percent probability of correct target identification at 500 meters against heavy tactical vehicles under reasonably demanding environmental conditions.

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	FY 2002	FY 2003	FY 2004	FY 2005
Optical Tags	0.655	0.000	0.000	0.000

(U) The Optical Tags program investigated optical technologies and innovative design and fabrication techniques for kilometer-range optical tag systems, which provide a quantum leap in tactics and operations in a wide variety of applications. The Optical Tags program validated models to predict system performance in support of a selected set of applications for technology demonstration. The applications were selected based on their operational significance and user input. The Optical Tags program developed systems performance requirements for the applications and demonstrated the systems in meaningful warfighter experiments. The technical successes and operational relevance demonstrated under this program has resulted in continuation of investigation of more robust optical tagging technologies in PE0602702E Project TT-04.

(U) Program Plans:

- Designed and tested portable interrogator and detector system to support testing of the tags at ranges in operationally representative field environments.
- Developed and tested remote tag emplacement method.
- Developed an eye safe tagging and interrogator system.
- Improved the response efficiency of the tags.
- Demonstrated system operation at operationally relevant ranges.

	FY 2002	FY 2003	FY 2004	FY 2005
Advanced Sensing Technologies	2.660	3.000	2.481	0.000

(U) The Advanced Sensing Technologies program will develop a new class of sensors for military surveillance and targeting applications. These sensors will provide surveillance, target detection, tracking, and classification, in day or night and in near all-weather conditions, of time critical mobile targets at distances greater than ten times current capabilities. Such capabilities are required to maintain battlespace dominance in challenging environments where sensor shadow zones may exist, such as around man-made and natural terrain obstacles, under forest canopies and within dense foliage.

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(U) Program Plans:

- Develop enabling technologies.
- Develop and field test stationary sensor system to detect, localize and characterize targets.
- Complete preliminary assessment of mobile sensor system to detect, localize and characterize targets in challenging environments.

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

- Not Applicable.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Future Combat Systems LNW-03	113.550	124.861	62.990	14.712	0.000	0.000	0.000	0.000

(U) <u>Mission Description:</u>

(U) The U.S. Military requires flexible, effective and efficient multi-mission forces capable of projecting overwhelming military power worldwide. This force must ultimately provide our national leaders with increased options when responding to potential crises and conflicts. To satisfy this requirement, the joint Army/DARPA Future Combat Systems (FCS) program was developed to provide enhancements in land force lethality, protection, mobility, deployability, sustainability, and command and control capabilities.

(U) <u>Program Accomplishments/Planned Programs:</u>

	FY 2002	FY 2003	FY 2004	FY 2005
FCS Concept Development	30.000	48.000	0.000	0.000

(U) The FCS program will develop network centric concepts for a multi-mission combat system that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly survivable in combat through the use of an ensemble of manned and unmanned ground and air platforms. The goal of the FCS program is to design such an ensemble that strikes an optimum balance between critical performance factors, including ground platform strategic, operational and tactical mobility; lethality; survivability; and sustainability. This system of systems design will be accomplished by using modeling, simulation and experimentation. The FCS unit will be capable of adjusting to a changing set of missions, ranging from warfighting to peacekeeping, as the deployment unfolds. An FCS-equipped force will be capable of providing mobile-networked command, control, communication and computer (C^4) functionalities; autonomous robotic systems; precision direct and indirect fires; airborne and ground organic sensor platforms; and adverse-weather reconnaissance, surveillance, targeting and acquisition.

(U) Program Plans:

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- Conducting concept and technology demonstration (CTD) to support decision for transition to System Development and Demonstration.
- Selected single Lead Systems Integrator to carry out CTD program in partnership with the Government.
- Conducted Technology Investment Decision Review.
- Completing Technology Maturity Assessment.
- Transition program from concept and technology development to system design and demonstration.
- Initiate Force Development Testing and Evaluation activities including limited man-in-the-loop testing.
- Initiate concept and technology demonstration (CTD) for follow-on block improvements.

	FY 2002	FY 2003	FY 2004	FY 2005
FCS Supporting Technologies	83.550	76.861	62.990	14.712

(U) DARPA identified six key areas where technology development is needed to support the overall FCS system of systems design: robotic perception, unmanned ground combat vehicles, maneuver command control and communication (C^3), beyond line of sight fires, organic adverse weather unmanned air vehicles and advanced laser radar sensors.

(U) The Perception for Off-road Robotics (PerceptOR) program will identify and develop revolutionary unmanned vehicle perception prototypes. These perception systems will be flexible enough to operate in off-road environments and will be backed by extensive experimental test data in a variety of operationally relevant terrain and weather conditions. The resulting technology will be applicable to a variety of combat roles and will enable greater confidence in postulating the conditions under which unmanned off-road robotics should be used. The use of advanced remote imagery and small numbers of collective robots will be included in the approaches taken.

(U) The Unmanned Ground Combat Vehicle program will develop vehicle prototypes exhibiting advanced performance in endurance, obstacle

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negotiation, and transportability (small size) based on novel designs unrestrained by the need to accommodate human crews. These prototypes may include unique mobility configurations (traditional wheeled/tracked to organic-mimicking, i.e. walking/crawling), exceptional drivetrains, advanced structures/composites, terrain/soil analysis, sensory exploitation and interaction with robotic control architectures.

(U) The Maneuver C^3 program will develop robust, assured and potentially high data rate connectivity for the Future Combat Systems (FCS) elements along with a command and control architecture to reduce the number of forward deployed Command and Control (C^2) operators. The communications component will develop an integrated architecture that provides for a seamless transition from line-of-sight to non-line-of-sight communications. To enable this functionality, development of new secure waveforms, directional antennas and mobile ad hoc networks will be initiated. The C^2 component will directly leverage the Army's investment in the automation of the Battlefield Functional Areas within the Army Battle Command System (ABCS). Because of the multitude of single aspect systems that feed information in ABCS, large amounts of data are made available to the commander, thus requiring a much larger staff of operators and workstation analysts to complete the fusion function of battlefield data into information for the commander to make decisions. Future operations involving FCS technologies and operational capabilities cannot be restricted by a less responsive C^2 architecture and large support staffs.

(U) The FCS C^2 program integrates and compresses selected Battlefield Functional Area functions in a scaled architecture to support the FCS Unit Cell operations. Through emulation of advanced information technologies and knowledge base engineering, this program will develop an advanced method of command and control, to integrate the previous stove-piped Battlefield Functional Areas into a single integrated information environment (Commander's Support Environment, CSE) that will support the command and control of manned and unmanned systems. The technical approach is to regulate the flow of information presented to an FCS Commander by moving much of the information/data integration to a hardware/software environment thus allowing the Commander and Battle Managers to leverage existing operational opportunities by focusing on fewer unknowns, clearly visualize current and future operational end states and dictate the tempo of operations within a variety of environments, while being supported by a significantly reduced staff. The true compression and integration of these functions would provide the FCS commander with information for rapid decision making vice numerous data streams requiring analysis by a large battle staff. The compression of these selected functions would enable a reduction of personnel in the Unit Cell C^2 element, and facilitate anticipatory planning and adaptive execution by the FCS Commander. A top level C^2 architecture (systems and operational) will be developed and validation of the architecture and assessment of performance (e.g., command latencies) will be achieved by conducting a series of four experiments within a simulated environment.

(U) The Netfires (formerly Advanced Fire Support System) program will develop and test a containerized, platform-independent multi-

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mission weapon concept as an enabling technology element for FCS. NetFires will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support and lower life-cycle costs, while increasing survivability compared to current direct fire gun and missile artillery. NetFires will allow FCS to defeat all known threats, will be air deployable in C-130 (and smaller) aircraft, and will enhance the situation awareness and survivability of FCS by providing standoff target acquisition and extended-range, non-line-of-sight engagements. The program will develop and demonstrate a highly flexible modular, multimission precision missile and a loitering attack missile that can be remotely commanded. Both missile types will have a self-locating launcher and a command and control system compatible with FCS.

(U) The Organic Adverse Weather Air Vehicle program provides FCS direct and indirect weapons system targeting under all operating conditions at the small unit level. The approach is to develop adverse weather vehicles for operation at two tiers; an upper tier for wide area coverage and a lower tier that allows a close-up view for positive target identification. For the higher tier, the A160 Vertical Take Off and Landing Unmanned Air Vehicle program will develop a vehicle for carrying out airborne surveillance and targeting against ground targets. The A160 vehicle will further provide an airborne communications/data link relay between the various ground components and the command nodes and satellite communications. In addition, the A160 will deploy unmanned ground sensors, unmanned ground vehicles, and Micro Air Vehicles (MAVs) and provide a data link between them and the C^2 components. For the lower tier, the Organic Air Vehicle program will develop 2 different sizes: 1) very small backpack-able (less then 10 1bs) and 2) small (less than 75 lbs) air vehicles that can fly autonomously in adverse weather. It will leverage DARPA Micro Air Vehicle program technologies and design a ducted fan vehicle that is scalable between 9 and 29 inch outside diameter to accommodate varying missions and payloads.

(U) The Jigsaw program will develop advanced laser radar (LADAR) sensor systems and technologies for day/night target identification and verification in stressing environments. Stressing environments include targets hidden by foliage and camouflage, and targets in urban settings, such as alleyways and alcoves. The sensor systems and technologies developed under this project will support the needs of FCS and will enable human observers to perform combat identification reliably and confidently through a visualization of the target scene by the LADAR sensor(s).

(U) Program Plans:

- PerceptOR.
  - -- Conduct perception system prototype development testing in both laboratory and field.
  - -- Conduct evaluation experiments on early perception system prototypes in variety of terrain and environmental conditions.
  - -- Conduct algorithm development for advanced perception behavior.

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-- Continue algorithm and supporting technology developments for unmanned maneuver.
-- Update prototype algorithms and hardware based on supporting experimentation.
-- Explore system implications of degraded component performance (communications constraints, sensor and other faults).

– Unmanned Ground Combat Vehicle (UGCV).
-- Complete critical subsystem testing and detailed prototype designs.
-- Select two designs for full prototype fabrication.
-- Initiate prototype fabrication.
-- Conduct UGCV surrogate tests.
-- Conduct testing of prototypes against mobility, endurance, and payload fraction metrics.
-- Conduct resilience testing on prototypes and make reliability measurements.
-- Update prototype hardware with late development technology and prepare for extreme testing conditions.

– Maneuver $C^{3.}$
-- Validate organic, self-contained approaches versus approaches that “reachback” to other systems for C^2.
-- Select wireless communications network architecture(s) for implementation.
-- Demonstrate sub-system components for assured communications in a hostile environment using novel waveforms and beam steering antennas for low probability of detection and anti-jam.
-- Refine Commander’s Support Environment (CSE); expand CSE knowledge base and collective intelligence module.
-- Continue to refine and expand supporting simulation.
-- Collect and assess the insights of human-machine interface requirements for training prototypes with the assistance of Army Research Institute.
-- Conduct experiments #2 and #3 in support of selected command and control functions for operations with manned/unmanned systems.
-- Complete the development of an initial C^2 experimental demonstrator.
-- Continue experiments of Unit Cell C^2 incorporating limited activities of the dismounted soldier.
-- Extend C^2 architecture to handle inter-unit cell operations, and operations between unit cell and next higher level.
-- Demonstrate an integrated architecture that provides seamless transition from line-of-sight to non-line-of-sight communications

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via unmanned aerial vehicles and satellite communications.
- -- Demonstrate new secure communication waveforms and mobile ad hoc networks using directional antennas.

– Netfires.
- -- Complete controlled test vehicle demonstrations and initiate guided test vehicle demonstrations.
- -- Conduct critical design reviews.
- -- Investigate coordination of multiple Netfires missiles.

– Organic Adverse - Weather Targeting Vehicles.
- -- Select platform and sensory payload for detailed design and prototyping efforts.
- -- Complete flight testing of initial sizes for OAVs.
- -- Initiate detailed design efforts for different size Organic Air Vehicles to flight demonstrate the design code and scalability of the technology.
- -- Ground test A160 anti-icing systems, sand/dust/salt protection systems, and precision flight systems.
- -- Demonstrate initial OAV gust stability and inner loop control.
- -- Demonstrate second-generation OAV autonomous navigation and auto-landing capabilities.
- -- Continue prototype platform development and sensory payload.
- -- Complete A160 satellite communications, survivability and resupply studies.
- -- Demonstrate third-generation OAV flight in rain, icing and adverse weather.
- -- Demonstrate OAV waypoint flight with collision avoidance in stressing environments.

– Jigsaw: LADAR Sensing for Combat ID.
- -- Conduct critical design reviews for prototype LADAR sensors.
- -- Build prototype LADAR sensors for airborne captive carry operation.
- -- Conduct data collection using prototype LADAR sensors.
- -- Quantify Combat ID performance of LADAR sensor against stressing targets.

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

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	FY 2002	FY 2003	FY 2004	FY 2005
PE 622601 Army	9.346	0.000	0.000	0.000
PE 633005 Army	103.417	114.351	114.051	111.102

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COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	0.000	0.000	95.654	151.966	205.382	183.796	200.335	203.073
Joint Warfare Systems NET-01	0.000	0.000	24.144	44.768	48.925	49.833	58.570	61.438
Maritime Systems NET-02	0.000	0.000	19.685	34.327	41.586	43.482	45.391	49.248
Classified NET-CLS	0.000	0.000	51.825	72.871	114.871	90.481	96.374	92.387

(U) <u>Mission Description:</u>

(U) The Network-Centric Warfare Technology program element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to develop and rapidly mature advanced technologies and system concepts for today's network centric warfare concept. It is imperative for the future of the U.S. forces to operate flawlessly with each other, regardless of which Services and systems are involved in any particular mission. The overarching goal of this program element is to enable technologies at all levels, regardless of Service component, to operate as one system.

(U) The Joint Warfare Systems project will create enabling technology for seamless joint operations from high-level, strategic planning to low-level, tactical operations. The operational benefits of this project will be an enhanced ability to counter opponents' capabilities, not just facilities and equipment. This project includes efforts at the strategic/operational level that generates targeting options against opponents' centers of gravity having complex networked relationships, the operational/tactical level that manages highly automated forces with tight coupling between air and ground platforms, and the focused tactical level that develops targeting platforms that can acquire targets of opportunity cued by network-based analysis of likely enemy operations. Programs in the project are closely coordinated with those in project NET-02 of this program element and those in PE 0603764E.

(U) The Maritime Systems project will identify, develop and rapidly mature critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Naval forces play an ever-increasing role in network centric warfare because of their

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forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea and their versatile ability to provide both rapid strike and project sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces. Programs in this project are closely coordinated with those in project NET-01 of this program element and those in PE 0603763E.

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

	FY 2002	FY 2003	FY 2004	FY2005
Previous President's Budget	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	95.654	151.966
Total Adjustments	0.000	0.000	95.654	151.966
Congressional program reductions	0.000	0.000		
Congressional increases	0.000	0.000		
Reprogrammings	0.000	0.000		
SBIR/STTR transfer	0.000	0.000		

(U) Change Summary Explanation:

FY 2004 – 2005 New program element and projects. Programs transferred from PE 0603763E and PE 0603764E in addition to new efforts in these years.

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Joint Warfare Systems NET-01	0.000	0.000	24.144	44.768	48.925	49.833	58.570	61.438

(U) Mission Description:

(U) The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical operations. By leveraging current and emerging network, robotic and information technology, next generation U.S. forces will realize greatly expanded capability, lethality, and rapid responsiveness, particularly through the use of light, highly mobile weapon systems. The critical constraints facing this project are: 1) U.S. opponents are using and adapting network technology to make their systems more flexible and robust and more difficult to neutralize; and 2) we will be expected to limit the use of firepower and lessen the impact of operations on noncombatants. These two challenges require an understanding of opponent networks, the creation of options to target them, and synchronized air and ground operations (from all services) to apply force only where needed and with specific effects, while still being able to operate against fleeting targets of opportunity. The operational benefits of this project will be an enhanced ability to counter opponents' capabilities, not just the facilities and equipment. This project will support all levels of the force structure including: 1) the strategic/operational level, by generating targeting options against opponents' centers of gravity that have complex networked relationships; 2) the operational/tactical level, by managing highly automated forces with tight coupling between air and ground platforms; and 3) the focused tactical level, by developing targeting platforms that can acquire targets of opportunity cued by network-based analysis of likely enemy operations.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Effect Based Network Targeting	0.000	0.000	6.939	13.877

(U) The Effects-Based Network Targeting program will develop technology to identify, determine vulnerabilities, target and anticipate workarounds in enemy networks. These techniques will use all-source information to continuously update models of urban networks (e.g., transportation, energy, social). Techniques will be developed to elicit operational objectives for urban interventions, expressed in terms of desired and undesired effects. It will use these objectives to find vulnerabilities in the networks, and nominate targets simultaneously to maximize desired

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effects while minimizing undesired effects. Finally, this program will develop techniques to predict observables that rapidly identify an opponent's response when several courses of action are available. The program will provide a capability to develop effects-based target sets at forward command nodes, permitting disruption of opponents networked systems such as communications, logistics and support. It will also provide a mechanism to anticipate and counter an opponent's workarounds while minimizing undesired effects through the anticipation of downstream consequences and through the selection of targets with low risk of collateral damage; thus permitting targeting operations to proceed within restrictive rules of engagement.

(U) Program Plans:

- Develop tools to extract relevant information from source data (especially signals, text and imagery), correlate that information to existing models, update the models while resolving conflicts among sources and analyze the overall effect of newly discovered changes.
- Develop tools to analyze networks, both in isolation and in combination, to identify vulnerabilities and to predict effects of candidate interdictions.
- Demonstrate selected tools on real-world cases, validating them against historical and natural situations.

	FY 2002	FY 2003	FY 2004	FY 2005
Future Combat Systems MultiCell and Dismounted Command and Control	0.000	0.000	6.938	11.894

(U) The Future Combat Systems MultiCell and Dismounted Command and Control program will develop and support experimentation with advanced command and control information technology for highly networked joint operations. It will emulate the functionality of a tactical cell, incorporating both unmanned air and ground robotic platforms, expanded to include multiple cells, higher headquarters working at the operational level, and human dismounts. Computational needs and automated battle command processes will be assessed. The program will develop planning factors for multiple entities from simulated ground operations including dismounted commanders and soldiers, both constructive and virtual. It will evaluate command effectiveness improvement from the use of automation technology by functionally analyzing command group behaviors and critical compound group functions and also recommend interface functions and workload. The program will provide an experimentally validated understanding of the dynamics of command in complex organizations containing highly automated forces. Commander interface

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layouts, functions and displays for maximum flexibility and effectiveness will be defined. It will generate recommendations for capability enhancements in supporting technology for the nomination of sources of information and support visualization of current and future operational states. Finally, this program will permit future command and control operations to be supported with a significantly reduced staff.

(U) Program Plans:
- Develop prototype command and control interfaces for higher commanders, cell commanders and dismount commanders.
- Conduct human-in-the-loop experiments with dismounts and higher headquarters to understand interactions between these entities.

	FY 2002	FY 2003	FY 2004	FY 2005
Confirmatory Hunter Killer System	0.000	0.000	6.822	16.545

(U) The Confirmatory Hunter-Killer System program will develop a low-cost, expendable loitering weapon/unmanned air vehicle for deployment along lines-of-communication or near critical facilities (e.g., suspect underground facilities) to provide continuous surveillance against limited (one or two) specific target classes with on-board electro-optics/infrared or low cost radar (motion cue or imagery based detection) sensors. It will develop and demonstrate an on-weapon automatic target recognition capability to detect the presence of valid target vehicle and confirm engagement with operator, as well as demonstrate the capability to provide image based, long duration suppression of non-emitting surface-to-air missiles and surface-to-surface missiles. The program will provide persistent, on-station munitions that enable rapid weapon response to emerging targets. Unmanned mechanisms will be developed that will patrol lines of communication and other delimited regions to prevent breakout, escape and reinforcement. The program will provide a capability to suppress emergent targets from suspect underground facilities. Finally, it will provide a capability to suppress pop up electronic warfare threats, before they emit.

(U) Program Plans:
- Characterize component capabilities (platform, sensor, on-board automatic target recognition and data links).
- Develop and analyze alternative designs, using high fidelity simulation and analysis tools, in a variety of joint mission contexts.
- Select combinations of components that achieve the most effective system capabilities.

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- Develop a brass board platform, mountable on a standard test aircraft, to verify sensor, automatic target recognition and data link performance.
- Tailor and improve component capabilities to reduce manufacturing cost while preserving effectiveness.
- Construct prototype vehicles and conduct field tests.

	FY 2002	FY 2003	FY 2004	FY 2005
Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD)	0.000	0.000	3.445	2.452

(U) The primary goal of the MAV ACTD program is to further develop and integrate MAV technologies into militarily useful and affordable backpackable systems suitable for dismounted soldier, marine, and special forces missions. It will focus on the development of MAVs to accomplish unique military missions, particularly with regard to flight operations in restricted environments. The objective of the MAV ACTD is to demonstrate a backpackable, affordable, easy-to-operate, and responsive reconnaissance and surveillance system. The system will provide the small unit with militarily useful, real-time combat information of difficult to observe and/or distant areas or objects. The system will also be employable in a variety of warfighting environments. For example, it will be beneficial in complex topologies (i.e. mountainous terrain with caves), heavily forested areas/dense foliage/triple canopy jungle, confined spaces (often internal to buildings) and high concentrations of civilians (where it may be critical to determine the neutral or hostile intent of a crowd). The initial MAV technology development program focused on the technologies and components required to enable flight at small scales, including flight control, power and propulsion, navigation and communications. It successfully demonstrated a new class of air vehicles, MAVs, which are at least an order of magnitude smaller (between 15 and 23 cm in diameter) than previously available flying systems. The MAV ACTD program will also leverage other DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectromechanical Systems (MEMS), advanced sensors, advanced electronic packaging technologies, and lightweight, efficient high-density power sources. In FY 2003, this program is funded from PE 0603764E, Project LNW-01.

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(U) Program Plans:

- Demonstrate electric MAV in military operations in urban terrain exercises and conduct experiments with troops in field trials.
- Evaluate lessons learned and design of a diesel MAV.
- Conduct further experiments with troops in the field to complete detailed design of hybrid MAV.
- Conduct experimentation of hybrid MAV; evaluate lessons learned; provide optimum MAV for evaluation.
- Conduct experimentation of optimum MAV and complete final military evaluation.

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

Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD)	FY 2002	FY 2003	FY 2004	FY 2005
PE 0603001A, Army	10.000	0.000	0.000	0.000
PE 0603750D, OSD	1.000	4.400	3.400	3.100

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COST (In Millions)	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009
Maritime Systems NET-02	0.000	0.000	19.685	34.327	41.586	43.482	45.391	49.248

(U) Mission Description:

(U) The objective of the Maritime Systems project is to identify, develop and rapidly mature critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Improvements in communications between and among submarines, surface ships and naval aircraft have allowed these forces to operate seamlessly with each other and with other Service's network centric systems. Naval forces will play an ever increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea and their versatile ability to provide both rapid strike and project sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces. This project funds the Loki program and Piranha program, which are closely coordinated with Project NET-01 of this PE and those in PE 0603763E.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Loki Program	0.000	0.000	14.764	17.654

(U) The Loki program has two major elements: the Vortex Combustor Development program and the Loki Systems Development program. The goal of these programs is to investigate revolutionary technologies that have high military payoff and turn them into coherent functional technology prototypes. Objectives include: (1) the development of an energy-dense, air independent underwater power source as a potential propulsion system for an underwater fighter, and 2) the investigation and development of detailed concepts of supporting systems and potential hull forms necessary for the operational viability of a future underwater fighter. Such an underwater vehicle would have the potential to revolutionize military and commercial undersea operations and the operational agility of maritime operations in the littoral. This program originated in PE 0603763E, Project MRN-02.

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(U) Program Plans:

- Vortex Combustor (VC).
  - Develop advanced control system, fabricate high power VC units, and conduct advanced tests.
  - Propulsion system design and fabrication.

- Loki Systems Development.
  - Continue structural, material and architectural trade studies, including: hydrodynamic performance modeling and system structural materials explorations.

- Continue concept of operations and military utility studies.
  - Component technology development, including:
    - -- Investigate novel communications and sensing modalities.
    - -- Explore autonomous control systems.
    - -- Investigate advanced propulsion systems concepts.
    - -- Initiate off-board cueing, communications and signature trade studies.

	FY 2002	FY 2003	FY 2004	FY 2005
Piranha	0.000	0.000	4.921	16.673

(U) The Piranha effort will enable submarines to engage elusive maneuvering land and sea targets by exploiting emerging battlefield Intelligence, Surveillance and Reconnaissance (ISR) sensors, wideband networked communications, real-time exploitation targeting algorithms, and existing/planned submarine strike weapon systems. Submarines are a key and enduring element of the current and future naval force with unique stealth, mobility, and endurance characteristics and are often the first strike unit on scene. Submarines have proven to be relatively immune to advances in weapons and information technology that increasingly put U.S. surface/air forces at risk, and their importance as an effective forward deployed strike asset is likely to continue to increase. This effort will develop key technologies that enable attack and cruise missile submarines to play a wider role in responding to time-urgent maneuvering targets from a forward-deployed position. The Piranha effort

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will focus on the following key technology areas that enable submarine strike missions in the littorals: continuous asymmetric connectivity to intelligence, sensors, weapons and other vessels while at depth; ISR sensor data exploitation for targeting (sensor-to-weapon handoff); advanced offboard sensor concepts to include swarms of mini unmanned underwater vehicles (UUVs) for sensing sea targets; mobile underwater Global Positioning System (GPS) concepts; undersea networked sensor communications; and low latency target detection, identification, and geo-referencing. The effort will pursue a progression of more realistic demonstrations, culminating in closed-loop submarine engagement of moving ground surface vehicles and sea targets. This program transitioned from PE 0603763E, project MRN-02 in FY 2004 to better reflect its inherent network centric emphasis.

(U) Program Plans:

- Assess concepts employing swarms of mini-UUVs as advanced sensor systems for littoral operations.
- Assess concepts for small area underwater mobile GPS systems.
- Develop prototype low cost mini-UUV sensor systems, undersea sensor communications, and a mobile underwater GPS capability.
- Design and prototype off-board Global Broadcast Satellite (GBS) antenna.
- Demonstrate endurance of underwater fiber optic link between global broadcast satellite antenna and moving platform.
- Receive operational ISR data over GBS at depth.
- Demonstrate Common Data Link (CDL) forward link to airborne receiver and receive tactical ISR data using CDL.
- Demonstrate closed-loop submarine engagement of a moving ground surface vehicle by a submarine using off-board and traditionally non-available sensors.

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

- Not Applicable.

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
RDT&E, Defense-wide BA6 Management Support	Management Headquarters (Research and Development) PE 0605898E, R-1 #126

COST (In Millions)	FY 2002	FY2003	FY2004	FY2005	FY2006	FY2007	FY2008	FY2009
Total Program Element (PE) Cost	36.102	42.271	45.002	46.489	46.382	46.318	47.169	48.030
Management Headquarters (R&D) MH-01	36.102	42.271	45.002	46.489	46.382	46.318	47.169	48.030

(U) Mission Description:

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical and information security, travel, supplies and equipment, communications, printing and reproduction.

(U) Program Accomplishments/Planned Programs:

	FY 2002	FY 2003	FY 2004	FY 2005
Management Headquarters	36.102	42.271	45.002	46.489

(U) Program Plans:
- DARPA will continue to fund civilian direct-hires, both career and Section 1101 employees, and administrative support costs. Anticipated pay raise requirements are also funded. Full compensation for all 40 section 1101 hires is reflected, including bonus packages.
- A substantial increase in security-related costs, including a major expansion of access controls, uniformed guards, and building security upgrades, are funded.
- CFO act compliance costs are funded.

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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA66 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E, R-1 #126

(U) **Program Change Summary:** *(In Millions)*	**FY 2002**	**FY 2003**	**FY 2004**	**FY2005**
Previous President's Budget	36.102	43.572	46.124	48.566
Current President's Budget	36.102	42.271	45.002	46.489
Total Adjustments	0.000	-1.301	-1.122	-2.077
Congressional program reductions	0.000	-0.143	0.000	0.000
Congressional increases	0.000	0.000	0.000	0.000
Reprogrammings	0.000	0.000	+0.302	-0.411
SBIR/STTR transfer	0.000	0.000	0.000	0.000
Shift of Agency CSRS contribution to OPM	0.000	-1.158	-1.124	-1.166
Payrate - Reductions	0.000	0.000	-0.300	-0.500

(U) Change Summary Explanation:

FY 2003	Decrease reflects congressional undistributed reductions and CSRS transfer to OPM.
FY 2004 – 2005	Decreases reflect inflation adjustments, payrate reductions, and transfer of CSRS payment responsibility back to OPM.

(U) Other Program Funding Summary Cost:

- Not Applicable.