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) Mission Description:

(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.

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(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		

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(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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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

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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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- 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.

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(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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(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) 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 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.

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(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) 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
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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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) Other Program Funding Summary Cost:

- Not Applicable.