RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	99.647	142.303	175.646	175.887	176.514	179.118	179.755	Continuing	Continuing
Bio/Info/Micro Sciences BLS-01	0.000	65.000	90.000	109.336	119.979	134.586	135.310	Continuing	Continuing
Information Sciences CCS-02	29.348	12.303	28.000	21.873	19.831	14.844	14.815	Continuing	Continuing
Electronic Sciences ES-01	22.488	25.943	20.000	19.879	16.873	14.844	14.815	Continuing	Continuing
Materials Sciences MS-01	47.811	39.057	37.646	24.799	19.831	14.844	14.815	Continuing	Continuing

(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 sciences, and attempt to exploit these advances in the development of new technologies 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 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1	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) a substantial increase 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 biomolecular materials, interfaces and microsystems; materials and measurements for molecular-scale electronics; spin-dependent materials and devices; and novel propulsion concepts.

(U) **<u>Program Change Summary:</u>** (*In Millions*)	**FY 2001**	**FY 2002**	**FY 2003**
FY02 Amended President's Budget	108.806	121.003	117.398
Current Budget	99.647	142.303	175.646

(U) Change Summary Explanation:

FY 2001	Decrease reflects the SBIR reprogramming and minor program repricing.
FY 2002	Increase due to the following congressional adds: Advanced Photonic Composites and Spectrum Laboratories, Nanotechnology Initiatives, Spin electronics and Ultra Performance Nanotechnolgy Center.
FY 2003	Increase reflects expansion of efforts in the Bio/Info/Micro Sciences project.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002

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

COST *(In Millions)*	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost to Complete	Total Cost
Bio/Info/Micro Sciences BLS-01	0.000	65.000	90.000	109.336	119.979	134.586	135.310	Continuing	Continuing

(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 organisms levels. New capabilities and methods for performing complex military operations will arise by applying lessons learned from the models provided by living systems that function and survive in a complex environment and adapt to changes in that environment. The combination of biological science and technology offers an avenue into the understanding and development of systems that are capable of complex, robust, and adaptive operations using fundamentally unreliable components. The tools developed will enable radically new command capabilities to deal with increased complexity in warfare, while addressing the increasing demands being placed on warfighters. This project will explore the information architectures that enable key communications between these biological elements and the physical basis for predicting structural and functional relationships, as well as the application of biological principles to the advancement of information and physical sciences. A number of key focus areas have been identified including: multidisciplinary programs in BioComputational Systems; Simulation of Bio-Molecular Microsystems; Bio Futures; Biological Adaptation; Assembly and Manufacture; Nanostructure in Biology and Brain Machine Interface program. A component these programs offer will be the identification, development and demonstration of new mathematical algorithms that enable the representation of biological systems and the identification of the emergence of biologically inspired algorithms for these complex, non-linear problems.

(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. First, combining methods for coding information in DNA and related nucleotides, with the massive parallelism capability of nucleotide manipulations, the synthetic computation effort aims to 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 seeks to improve time efficiencies and manufacturing capabilities of biological systems production hardware by miniaturizing it to a circuit board size system. Self-assembly of DNA will be exploited to develop programmable

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

nano-structures and engineered nano-technology for use in layout of molecular electronic devices, reliable crystallography, and for design of novel materials. 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) 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. SIMBIOSYS will explore fundamental properties and compatibility of biological elements at surfaces 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. Specifically the SIMBIOSYS program will develop methods and tools to simulate and design Bio-Molecular Microsystems with a high degree of multi-disciplinary integration.

(U) The Bio Futures program will support scientific study and experimentation, emphasizing biological software, computation based on biological materials, 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. Genomics–based platforms will enable rational medical drug discovery and broadspectrum antibiotics discovery for pathogens confronting the warfighter.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

(U) The Biological Adaptation, Assembly and Manufacturing program will examine the structure, function, and informational basis for biological system adaptation, assembly and manufacturing of complex systems. 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 labile 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 labile systems of interest. 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.

(U) The Nanostructure in Biology program will investigate the nanostructure properties of biological materials in order to better understand their behavior and thereby accelerate their exploitation for Defense applications. The tools and approaches developed under this program will 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. 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

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

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) 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. Close-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. In addition, these emerging methods for viewing and measuring processes within the brain will be leverage to determine if it is possible to detect deceptive intent.

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

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

- Not Applicable.

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

- BioComputational Systems. ($27.000 Million)
  - Initiate the investigation of scalable computing mechanisms using DNA manipulations.
  - Investigate the use of biomolecular (e.g., DNA) and other biological elements (biochemical pathways, cells) as an ultra-compact, massive storage mechanism with tagging and associative search capability.
  - Implement methods for creating programmable two-dimensional nano-structures based on DNA fragments.
  - Explore the design of multi-state bio-based synthetic logic circuits for monitoring and reporting states as well as for process control.
  - Initiate open source development of spatio-temporal computational models and software of internal cellular processes.
  - Specify architecture for software development for creation of Bio-SPICE: Simulation Program for Intra-Cell Evaluation.
  - Initiate software integration of components leading to Bio-SPICE and its ongoing iterated development.
  - Initiate experiments at the cellular level to evaluate, confirm and validate models of intra-cellular processes of interest to DoD such as host-bacterial engagements and processes such as molecular level rhythms that may impact on warfighter performance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	**DATE** February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	**R-1 ITEM NOMENCLATURE** Defense Research Sciences PE 0601101E, Project BLS-01

- Initiate investigation of a biologist friendly cellular process simulation tool, including database definitions and user interface tools.
- Examine computational abilities of networks of cells and organized groups such as schools or swarms.
- Examine control methods of communication and regulation of activities in cells and organized groups of cells or organisms, such as colonies or mats.
- Develop preliminary miniaturized hardware designs for microchemical oligonucleotide manufacture, manipulation and amplification proof of principle brassboards. Initiate studies on error correction and optimal information encoding of microchemical oligonucleotides.

• Simulation of Bio-Molecular Microsystems (SIMBIOSYS). ($14.000 Million)

- Engineer biological circuits and architectures that optimize compatibility and information transfer between biological and non-biological materials to improve the interaction and integration of biological elements with synthetic materials in the context of microsystems.
- Develop methods to characterize interfaces that allow one- and two-way communications, smart control, longevity and stability.
- Create instrumentation and tools that will improve experimental validation of models that explore biological systems at interfaces.
- Develop and validate phenomenological models for a range of signal transduction processes.
- Develop data and models on electrokinetic transport and surface tension driven flows in microsystems.
- Investigate novel hybrid macro-molecular devices that form specific and controlled transducing functions at the molecular scale.

• Bio Futures. ($8.619 Million)

- Demonstrate single molecular imaging in living cells. Demonstrate imaging of single molecular species in a living bacterial cell.
- Demonstrate the application of novel nano-devices to measure, manipulate and control cells, tissues, and biomolecules.
- Exploit nanoscale fluidic phenomena to achieve control of molecular level activity interrogation and control.
- Develop nanofluidic interfaces for selective transport of multi-scale bimolecules.

• Biological Adaptation, Assembly and Manufacture. ($5.381 Million)

- Identify and optimize strategies for manipulating cell and tissue survival in response to exogenous stimuli including stressful conditions.
- Examine pluripotential and totipotential cells for principles of assembly, manufacture and long term survival.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Define the engineering parameters for biomechanical systems; develop computational models of biomechanics that can be used to design and engineer new mechanical systems that mimic biomechanical system performance.
- Examine methods of control for directed cell proliferation and cellular stasis at the tissue and organismal level.
- Define parameters for successful application of device for optimizing engineered cells in stasis, differentiation, biopolymers and ablation.
- Examine neural codes for motor and sensor activity.
- Determine open and closed loop controls for using neural signals to control peripheral devices.

• Nanostructure in Biology. ($10.000 Million)
- Explore novel techniques for atomic resolution, three-dimensional non-destructive imaging of biomolecules.
- Form multidisciplinary teams to build high sensitivity magnetic resonance force microscopes.
- Demonstrate a scalable process for producing bio-compatible magnetic nanoparticles (10-100 nm diam.) with stable and reproducible magnetic properties and less than five percent variation in nanoparticle diameter.
- Demonstrate a biocompatible magnetic sensor capable of detecting a single magnetic nanoparticle with diameter less than 100nm.
- Identify and model specific cellular signaling pathways to be investigated using magnetic actuation.

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

• BioComputational Systems. ($35.000 Million)
- Implement scalable information processing using DNA coding and manipulations and demonstrate example with a twelve variable graph problem known to be complex as it scales.
- Demonstrate a compact DNA based information storage mechanism with thousands of information objects.
- Exploit self-assembly of DNA structures to achieve arbitrary two-dimensional nano-structures, and explore three-dimensional implementations.
- Implement a first version of the cell models of computation that capture spatio-temporal nature of gene and protein interactions in cells.
- Test and validate the models using first set of data collected from experiments on host-pathogen interactions and molecular level rhythms.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Release first integrated version of open source Bio-SPICE (Simulation Program for Intra-Cell Evaluation) for use in biological experimentation.
- Initiate development of Bio-SPICE architecture that enables easy access to public genomic and protein interaction databases, and distributed computing for cell simulation.
- Investigate methods for reduced order cell models and scalability in cell process simulation.
- Demonstrate ability of individual technologies to overcome current problems caused by the inability of numeric algorithmic processes to handle the growing complexity of future C^2 problems.
- Develop capability to utilize complex biological systems for multiple sequential linked events. Assess the possibility of designing a 'digital human' model for a broad spectrum of applications.
- Investigate parallels between biological and non-biological signal processing via advanced modeling and experimentation tools.
- Finalize miniaturized hardware designs for microchemical oligonucleotide manufacture, manipulation, and amplification proof of principle brassboards and initiate development.
- Complete studies on error correction and optimal information encoding of microchemical oligonucleotides.

- Simulation of Bio-Molecular Microsystems (SIMBIOSYS). ($15.000 Million)
  - Engineer living circuits at material interfaces that perform pattern recognition and information processing.
  - Design working devices that incorporate living components as sensors, actuators and computational devices.
  - Explore the utility of using virtual representations of biological systems to specify their engineering properties.
  - Develop scaling laws and phenomenological models for bio-molecular and fluidic transport.
  - Implement models for molecular binding, signal transduction and bio-fluidic transport into microfluidic system software.
  - Investigate methods to extract and integrate several bio-molecular devices on synthetic substrates to form larger scale systems.

- Bio Futures. ($9.130 Million)
  - Develop new engineering tools for designing and enhancing biological regulatory circuits.
  - Develop functional nanofluidic sensors based on cells or cellular components for high sensitivity sensing.
  - Demonstrate nano-scale fluidic systems for the decoupling, quantification and transduction of multi-scale biomolecular signatures.
  - Demonstrate enhancement of natural metabolic capabilities via design-based approaches to genetic engineering.
  - Demonstrate novel nano devices for measuring and regulating cell physiology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

– Demonstrate biological systems and interfaces, which are self-repairing and retain functional activities over long periods of time.

- Biological Adaptation, Assembly and Manufacture. ($9.500 Million)
  – Transfect and up-regulate genes, or gene products, that produce high-grade tolerance to the stresses of freezing or drying of living cells.
  – Demonstrate application of desiccation tolerance to nucleated and non-nucleated cells.
  – Demonstrate viable integration of genetic strategies for metabolic regulation of living cells.
  – Develop design rules for manufacturing and assembly based on biological principles of development.
  – Develop biofilm utility for DoD needs; including integrated chemical and biological sensing, power generation, antibiotic discovery and concepts of disease transmission.
  – Demonstrate approach of materials manufacturing to organ construction.
  – Demonstrate functional application of desiccated blood components for in vivo application.
  – Develop technologies for making genetic, signal transduction, and metabolic circuits so that organisms (e.g. plants) can be used for detecting chemical and biological materials of interest to DoD (e.g. explosives and chemical and biological warfare agents.)

- Nanostructure in Biology. ($9.370 Million)
  – Demonstrate single electron spin sensitivity for a magnetic resonance force microscope.
  – Determine doping and defect profiles in nanostructures.
  – Perform spin labeled measurements of conformational changes in molecules.Demonstrate the ability to tailor the bio-functionality of nanoparticles to allow attachment (with a high degree of specificity) to a wide variety of cells and bio-molecules including DNA, antibodies, and known pathogens.
  – Demonstrate the ability, using magnetics, to manipulate and control single biomolecules and cells.

- Brain Machine Interface. ($12.000 Million)
  – Initiate extraction of neural and force dynamic codes related to patterns of motor or sensory activity.
  – 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 system or device.
  – 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Define new materials and device design and fabrication that embody compliance and elastic principles and capture force dynamics that integrate with neural control commands.
- Understand deception behavior of the brain and determine whether this behvior can be detected using non-invasive approaches such as infra-red brain imaging and correlated with remote monitoring techniques.

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

- Not Applicable.

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

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Information Sciences CCS-02	29.348	12.303	28.000	21.873	19.831	14.844	14.815	Continuing	Continuing

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

(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) Computer Exploitation and Human Collaboration will develop information technologies for warfighters to interact with computers in a mobile, intuitive fashion, and enable collaborations as well as intelligent exchange of information in a seamless fashion. Architectures for nomadic software, redesigns of classical notions of 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 is another important area of research in pervasive computing. This requires innovation in processing massive amounts of data (e.g., multi-INT) and in parallel processing efficiency. This project 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. This will create a more natural interaction and greatly reduce the overhead for the user. (Formerly Ubiquitous Computing and Human Computer Interface)

(U) Bio Futures is the combination of biology with information technologies and physical systems. Progress in biology will be greatly aided by the ability to understand and manipulate the massive data inherent in living systems. Microelectronics and sensors reached a level of systems sophistication and miniaturization that now can directly interface with biological cells. The fields of biological science and technology offer an understanding of systems complexity and robust operation using fundamentally unreliable components, and an understanding that will enable new approaches for information technology, computers and electronics. The Bio Futures effort supports scientific study and experimentation, emphasizing biological software, computation based on biological materials, physical interfaces between electronics and biology, and interactive biology. It will apply information technology to accelerate the analysis and synthesis of biological processes by applying statistical language modeling tools to the problems of rapid bio sequencing. The seamless integration of information technology and biological processes will provide the ability to exert computational control over biological and chemical processes and accelerated discovery of gene expression and protein-protein interactions. The applications will develop techniques using information theory for rational medical drug discovery and broad-spectrum antibiotics

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

discovery for pathogens confronting the warfighter. Another area of exploration, the Simulation of Bio-Molecular Microsystems (SIMBIOSYS), will develop and demonstrate the capability to simulate and design chip-scale bio-molecular micro-systems with a high degree of multi-disciplinary integration. Both Bio Futures and SIMBIOSYS transferred to the new Bio/Micro/Info Sciences Project (BLS-01) in FY 2002.

(U) The DARPA SPINE (Speech in Noisy Environments) program is creating a automatic speech recognition architecture with prototypes to support broadband and narrowband recognition complicated with tactical military noise such as vehicles, combat noise (weapons), multi-speakers and speech altered by speaker stress. Just as modern computers and calculators can outperform most if not all humans in calculating tasks, SPINE will take advantage of new sensory techniques to potentially outperform humans in the speech recognition domain. If the armed forces are to use automation and robotic technology to extend the force and free soldiers from logistical service support duties, then those information and automation assets must be controlled by natural speech (hands and eyes free) by operators in the field on mission. The technological challenges to such support include adaptation to speaker variation, reverberant noise and speech, operation in negative or low effective signal-to-noise ratios, and overcoming environmental noise variation. To overcome these challenges, the Automatic Speech Recognition (ASR) engine must perform blind source separation, automatic adaptation and learning, and have a greater understanding of noise and the acoustic features of speech. To create such a speech engine to drive our next generation dialog-based interfaces, SPINE must exploit such research topics as: binaural and cochlear hearing techniques, dynamic and graphical modeling, prosody, microphone arrays, advanced language models, and use of non-acoustic communication features.

(U) The Dependable Information Systems component will develop the technology to construct mission-critical military information-systems that will continue to function correctly and provide user services even in the face of component faults, cyber attacks, and attacks initiated by malicious insiders. Special focus of this research is on tactical military systems, embedded systems for communications, surveillance, high-resolution imagery and telescopic, and systems requiring near-real-time response. As these systems become increasingly interconnected in support of network centric warfare, security and fault-tolerance concerns unique to these systems are beginning to emerge. Solutions are being pursued that can work in near real time, dynamically trade performance, functionality and dependability, and heal the system faults and vulnerabilities automatically or semi-automatically with some operator assistance. In parallel, model-based theories of fault diagnosis, decentralized general-purpose algorithms for fault-adaptive distributed systems, fault recovery techniques, simulators for injecting and analyzing fault propagation through the layers of system architecture, and application-oriented experimental platforms are being developed. A theoretical framework will be developed, along with appropriate metrics, to measure the progress in this discipline. Three new initiatives include: Fault Adaptive Systems Technology (FAST), Dependable Architectures, and Self-Regenerative Systems. FAST will address scalable fault management technology that is independent of the application. Dependable Architectures will focus on the dependability of real-time systems and defense against malicious code and insider

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

threats. Self-Regenerative Systems will leverage the disciplines of threshold cryptography, software rejuvenation, self-stabilizing systems, and fault tolerance to create dependable systems.

(U) High-Speed Computer Information Systems Bandwidth and Wireless Technology Research focused on improving the end-computer-system bandwidth by an order-of-magnitude to enable true gigabit to terabit information transfer. These efforts ended in FY 2001.

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

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

- Ubiquitous Computing. ($2.684 Million)
  - Developed ad-hoc and indoor location tracking systems.
  - Demonstrated the first version of a small footprint operating system in an operational environment.
  - Developed initial prototype of secure, persistent data storage architecture.
  - Developed specification language and toolkit to program data-flow between heterogeneous devices supporting end-to-end quality of service.
  - Conducted initial data collection and baseline performance measures for current state of the art ASR engines using coded speech in tactical noise.

- Bio Futures. ($24.579 Million)
  - Biological and Amorphous Computing.
    - Demonstrated real-time multi-sensor imaging of cell processes in support of interactive biology.
    - Established focused research initiatives at the interface between biology, engineering and information sciences.
    - Demonstrated use of high resolution imaging technology and signal transduction to affect interactive control over simple biological systems.
    - Conducted investigation of the potential of amorphous computing, a biologically inspired computing paradigm, for development of reliable and robust decision tools and software.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02	

– Bio: Info: Physical Systems Interface.
  - - Explored fault tolerant hardware architectures, software techniques with the ability to self-heal and reprogram adaptively.
  - - Demonstrated modeling and control of genetic circuits, expression of proteins, protein-protein interaction and cellular function for rational medical drug design.
  - - Developed new hybrid devices combining biological and artificial components scaling from molecular-scale to population level.
  - - Created biologically inspired algorithms and models for computation, including systems of hybrid devices.
  - - Applied developments in biology, information science and materials science to dramatically improve the interactions of humans and systems.
  - - Determined feasibility of reducing oligonucleotide production, manipulation, and amplification to micro-chemical miniaturization processes and initiated development of process model.
  - - SIMBIOSYS: Developed and validated models, phenomenological relationships and scaling laws for a range of bio-molecular recognition processes in micro-systems.

- High-Speed Computer Information Systems Bandwidth. ($1.489 Million)
  – Developed technology enabling orders of magnitude improvement in reliability and performance in military wireless networks through joint adaptation of network protocols and wireless transmission methods including coding, modulation, and range.
  – Investigated information assurance methods for miniaturized wireless sensor networks.

- Wireless Technology Research. ($0.596 Million)
  – Initiated research on methods that can potentially enable orders of magnitude improvement in reliability and performance in military wireless networks through joint adaptation of network protocols and wireless transmission methods including coding, modulation, and range.
  – Completed investigation of the information assurance methods for miniaturized wireless sensor networks.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) **FY 2002 Plans:**

- Computer Exploitation and Human Collaboration. ($6.930 Million)
  - Complete development of specification language and toolkit to program data-flow between heterogeneous devices supporting end-to-end quality-of-service.
  - Develop new forms of human-computer interaction that enable human and computers to work as synergistic teams.
  - Investigate efficient processing that increases the speed of parallel processing.
  - Test on challenge datasets for image processing or superpositioning of information.
  - Investigate an adaptive visual display capability to maximize information conveyance.

- Speech in Noisy Environments (SPINE). ($4.750 Million)
  - Establish baseline high noise performance levels.
  - Refine scalable metrics for evaluations in military environments.

- Dependable Information Systems. ($0.623 Million)
  - Evaluate novel credentials-based infrastructure approaches for mitigating insider threats in large enterprise networks.

(U) **FY 2003 Plans:**

- Speech in Noisy Environments (SPINE). ($9.700 Million)
  - Incorporate core Automatic Speech Recognition (ASR) algorithms into new robust ASR prototype.
  - Define protocols, metrics, and scenarios for SPINE experimental tasks.
  - Establish data-type standards for multi-modal input devices (in support of plug-and-play and system independent design).
  - Baseline ASR components in worst-case noise environments.
  - SPINE-2 evaluation with coded speech in tactical noise.
  - Evaluate first year's core research for delivery to SPINE team performers.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Computer Exploitation and Human Collaboration. ($9.600 Million)
  - Develop efficient processing algorithms that increase the speed of parallel processing by factor of 10 exploiting new mathematical paradigms.
  - Test the algorithms in a warfighter intelligence environment.
  - Demonstrate scaling with computational powers of emerging processing algorithms.
  - Improve devices to perceptually deliver pertinent information to users.

- Dependable Information Systems. ($8.700 Million)
  - Fast Adaptive Systems Technology (FAST)
    - -- Develop application-independent model based algorithms for mission-level fault adaptation, system-level fault diagnosis.
    - -- Develop visualization, fault-injection, and simulation tools for validating fault management approaches.
  - Dependable Architectures.
    - -- Develop novel architectural approaches to detect malicious insider activity including discrimination between normal and anomalous insider behavior (based on a number of parameters such as key strokes, operating system calls, application usage etc); trace ability of system object usage (be able to determine who uses what, when, and how via watermarks, audit trails, event logs etc).
    - -- Develop methodologies for specifying security policies that are context sensitive, comprehensive, and consistent; and enforcement mechanisms that detect policies violation before damage is done by malicious code or malicious insider activity.
    - -- Develop mechanisms for continuous monitoring of user behavior and system actions to defeat malicious insider; develop novel response mechanisms (dynamic privilege modification and access revocation).
    - -- Develop defense mechanisms that exploit the inherent attributes of real-time mission-critical system architectures.
  - Self-Regenerative Systems.
    - -- Leverage the disciplines of threshold cryptography, software rejuvenation, self-stabilizing systems, and fault-tolerance.
    - -- Create a foundation for self-regenerative information systems.
    - -- Develop measures of merit and metrics of various aspects of information system dependability to allow researchers, designers, vendors, users and operators to make quantitative dependability evaluations.

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

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02	

(U) Schedule Profile:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Electronic Sciences ES-01	22.488	25.943	20.000	19.879	16.873	14.844	14.815	Continuing	Continuing

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

(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) This project is also concerned with coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components. Such components will be critical to enhancing the effectiveness of military platforms that provide warfighter comprehensive awareness and precision engagement. Topics to be researched include emitters, detectors, 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) 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. Previously funded by the Director, Defense Research and Engineering but managed by

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

DARPA, funding for this effort is now budgeted by DARPA to more closely align the resource authority with the managerial responsibility for the program.

(U) The Macro-Molecular Engineering Program will develop nanoscale engineering for macroscopic functionality incorporating biological warfare sensors, energy engineering and fast photo refractives.

(U) The Photonic Interconnection Fabric Program seeks to generate new communications, dominated signal/image processing architectures and introduce a new paradigm for parallel computing.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Terahertz Technology. ($5.627 Million)
  - Demonstrated the best semiconductor quantum-well approaches to sources for the terahertz spectral region.
  - Demonstrated semiconductor quantum-well detectors.
  - Identified system requirements to achieve space communications, upper-atmosphere imagery and close-operations covert communications.

- University Opto-Centers. ($12.826 Million)
  - Demonstrated initial chip-scale integrated photonic, electronic and MEMS modules.
  - Identified the most compelling DoD module applications and measured level of industry commitment to adopt chip-scale integration approach.

- Advanced Photonics Research. ($4.035 Million)
  - Developed photonic composite material modeling, design, growth, analysis, processing and device fabrication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) **FY 2002 Plans:**

- Terahertz Technology. ($2.192 Million)
  - Demonstrate compact sources and detectors capable to operate between 0.2 – 10 terahertz (THz).
  - Demonstrate terahertz, short-range detection system.
  - Assess experimental component performance and compare against system requirements for space communications, upper-atmosphere imagery and close-operations covert communications.

- University Opto-Centers. ($11.551 Million)
  - 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.

- Semiconductor Technology Focus Centers. ($6.000 Million)
  - 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.

- Advanced Photonics Research. ($4.200 Million)
  - Continue research in photonic composites and device fabrication.

- Spectrum Lab. ($2.000 Million)
  - Initiate technology development.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) FY 2003 Plans:

- University Opto-Centers. ($5.707 Million)
  - Design and fabricate prototype modules using the system-on-a-chip approach developed earlier in the program.
  - 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.

- Semiconductor Technology Focus Centers. ($9.000 Million)
  - Develop the interface methodology for efficient handling and compilation of design object information for complex military integrated circuits.
  - Develop circuit architectures that reduce long interconnect.
  - Develop novel device fabrication and integration approaches for deeply scaled transistors and architectures for high performance mixed signal circuits for military needs.

- Macro-Molecular Engineering. ($2.293 Million)
  - Develop BW sensor detectors.
  - Demonstrate photo refractive response time.
  - Demonstrate three-level system energy engineering.

- Photonic Interconnection Fabric. ($3.000 Million)
  - Demonstrate deeper level of photonic integration with CMOS.
  - Use VLSI-Photonic technology to develop system test beds.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01	

(U) **Schedule Profile :**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE February 2002
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 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	Cost To Complete	Total Cost
Materials Sciences MS-01	47.811	39.057	37.646	24.799	19.831	14.844	14.815	Continuing	Continuing

(U) Mission Description:

(U) This project provides the fundamental research that underpins the development of advanced materials for DoD applications. Included in this project is research that exploits advances in nanoscale and biomolecular materials, including computational based material 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).

(U) One of the major thrusts of this project 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) A new initiative in Engineered Bio-Molecular Nano-Devices and Microsystems seeks to engineer assemblies of organic and inorganic molecules showing tremendous promise as the basis for new types of nano-devices that can be assembled to form high performance microsystems. These microsystems will enable important new capabilities such as high sensitivity sensors and transducers for previously inaccessible optical, biological and chemical phenomenon.

(U) Program Accomplishments and Plans:

(U) FY 2001 Accomplishments:

- Nanoscale/Biomolecular Materials. ($6.574 Million)
  - Demonstrated enhanced performance from materials and processes incorporating nanostructured components.
  - Demonstrated the use of quantum chemistry for the theoretical design of new nanoscale/biomolecular/multifunctional materials and structures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Explored the interface between biological systems and abiotic surfaces and materials.

• Spin-Dependent Materials and Devices. ($12.050 Million)
- Demonstrated spin-polarized transport across ferromagnetic/semiconductor interfaces.
- Optimized spin lifetime in semiconductor structures.
- Demonstrated spin light emitting diode (spin-LED) and spin transistor.

• Spin Electronics. ($10.000 Million)
- Started multidisciplinary efforts to exploit the advantages of nanotechnology in spin electronics (spintronics).

• Molecular Electronics. ($8.337 Million)
- Demonstrated that molecules and/or nanoparticles can self-assemble into functional, regular patterns.
- Built and tested a 16-bit functional, reversible molecular memory sub-unit.
- Built and tested room temperature scalable logic gates using molecules.

• Advanced Drag Reduction (Fast Ship). ($6.550 Million)
- Completed integrated hydrodynamic model development at multiple scales.
- Completed laboratory-scale calibration and confirmation testing of initial model predictions.
- Developed model-based performance predictions of different potential drag reduction techniques.
- Confirmed drag reduction performance predictions from laboratory-scale testing.

• Nanoelectric Research. ($2.500 Million)
- Continued molecular and quantum-dot cellular automata nanoelectric research.

• Spectral Hole Burning. ($1.800 Million)
- Continued investigation of the applications of spectral hole burning.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

(U) **FY 2002 Plans:**

- Nanoscale/Biomolecular and Metamaterials. ($6.309 Million)
  - Develop approaches for synthesis of nanoscale/biomolecular materials based on encoded combinatorial synthesis of polymers.
  - Develop techniques for transferring information between cells and abiotic materials and surfaces.
  - Develop theoretical understanding of wave propagation in “left-handed” metamaterials.
  - Optimize processing schemes for engineering metamaterials with enhanced electromagnetic properties.
  - Model non-linear response of rectifying metamaterials.
  - Investigate and model the physics of nano-scale magnetic materials.
  - Develop approaches for predicting properties and structure of nanoscale and metamaterials using first principle/quantum mechanical models.
  - Explore approaches for integrating biological activities into materials fabrication and engineering.

- Spin-Dependent Materials and Devices. ($14.648 Million)
  - Demonstrate near room temperature spin light-emitting diode (spin-LED).
  - Demonstrate spin coherent optical modulators and switches operating at frequencies approaching a teraHertz.
  - Demonstrate an optically excited spin phase-logic device operating in the gigaHertz frequency range with very low dissipation.
  - Demonstrate conversion of an optical quantum bit (qubit) into spin quantum bit.

- Spin Electronics. ($15.000 Million)
  - Continue multidisciplinary efforts to move spin electronics into the nanoscale regime.
  - Couple spin electronics with molecular electronics, nano mechanics and nano photonics.

- Nanotechnology Initiative. ($1.000 Million)
  - Start multidisciplinary in nanotechnology.

- Ultra Performance Nanotechnology Center. ($2.100 Million)
  - Initiate efforts in ultra-performance nanotechnology and identify specific DoD targets.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

(U) **FY 2003 Plans:**

- Nanoscale/Biomolecular and Metamaterials. ($7.646 Million)
  - Produce and evaluate novel and/or cost-efficient materials using biological synthesis approaches.
  - Develop theoretical understanding of three dimensional exchange biased ferromagnetism in nanocomposite magnetic metamaterials.
  - Demonstrate the ability to predict, design and fabricate a metamaterial that exhibits a predetermined microwave response.
  - Develop and demonstrate a theoretical understanding and predictive modeling capabilities for metamaterials that exhibit "left-handed" properties and/or a negative index of refraction.
  - Conduct experiments to validate the first principle/quantum mechanical models for predicting properties and structure of nanoscale and metamaterials.
  - Continue to explore approaches for integrating biological activities into materials fabrication and engineering.

- Spin-Dependent Materials and Devices. ($20.000 Million)
  - Demonstrate a simple high speed, low power opto-electronic circuit using spin coherent devices.
  - Demonstrate electronically excited spin-coherent devices for high-speed digital circuits.
  - Demonstrate a very high-speed circuit using spin dependent transport devices.
  - Demonstrate a scaleable, spin-based implementation for quantum logic gates.

- Engineered Bio-Molecular Nano-Devices and Microsystems. ($10.000 Million)
  - Develop techniques to enable 3D heterogeneous integration and self-assembly methods spanning diverse technologies such as fluidics, MEMS, electronics and photonics.
  - Develop new and innovative technologies in the areas of architecture, design, growth, processing, 3D manipulation, control, interconnection, fabrication and integration of organic and inorganic materials.
  - Develop fabrication techniques that incorporate compact instruction sets for autonomous self-replication.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE February 2002
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01	

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

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.