RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research			R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E				
COST (In Millions)	FY 2005	FY2006	FY2007	FY 2008	FY 2009	FY 2010	FY 2011
Total Program Element (PE) Cost	165.101	133.308	150.690	153.460	156.242	159.959	162.596
Bio/Info/Micro Sciences BLS-01	53.879	44.042	46.266	49.645	53.925	54.925	55.925
Information Sciences CCS-02	23.791	19.933	29.481	32.687	30.627	31.314	32.951
Electronic Sciences ES-01	33.815	30.783	34.060	30.853	30.752	31.752	31.752
Materials Sciences MS-01	53.616	38.550	40.883	40.275	40.938	41.968	41.968

(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. Programs in this project will draw upon information and physical sciences to discover properties of biological systems that cross multiple biological architectures and functions, 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 Interfaces; Biological Adaptation, Assembly, and Manufacturing; Nanostructure in Biology; and Human Assisted Neural Devices.

(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 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E

(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 2005	FY 2006	FY 2007
Previous President's Budget	169.571	130.090	132.041
Current Budget	165.101	133.308	150.690
Total Adjustments	-4.470	3.218	18.649
Congressional program reductions	-0.130	-5.432	
Congressional increases	0.000	8.650	
Reprogrammings	0.000		
SBIR/STTR transfer	-4.340		

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E

(U) Change Summary Explanation:

FY 2005	Decrease reflects SBIR/STTR transfer and the DOE transfer directed in P.L. 108-447.
FY 2006	Increase reflects five congressional adds in the areas of biomedical engineering, quantum computing and infotonics offset by a congressional reduction to the Bio-computational program and undistributed reductions for Section 8125 and the 1% reduction for Section 3801: Government-wide rescission.
FY 2007	Increase reflects new emphasis in Project CCS-02 for the Computer Science Study Group; Project ES-01 to fund Carbon Nanotube RF Devices, Quantum Entanglement S&T (QUEST) and MEMS Science and Technology Focus Centers; and enhancement of Bio-Molecular thrusts in the Materials Sciences area, Project MS-01.

THIS PAGE INTENTIONALLY LEFT BLANK

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research			R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01				
COST (In Millions)	FY 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Bio/Info/Micro Sciences BLS-01	53.879	44.042	46.266	49.645	53.925	54.925	55.925

(U) Mission Description:

(U) This project is investigating and developing the intersections of biology, information technology and micro/physical systems to exploit important technological advances and leverage fundamental discoveries for the development of new technologies, techniques, and systems of interest to the DoD. This research is critical to the development of rapid responses to engineered biological warfare agents, radically new biomolecular computers, and novel materials for the DoD. Programs in this project will draw upon the information and physical sciences to discover properties of biological systems that cross multiple scales of biological architecture and function, from the molecular and genetic level through cellular, tissue, organ, and whole organism levels. This project will develop the basic research tools in biology that are unique to the application of biological-based solutions to critical Defense problems. This project is also providing the supporting basic research for the effort to revolutionize prosthetics.

(U) Program Accomplishments/Planned Programs:

	FY 2005	FY 2006	FY 2007
BioComputational Systems	9.237	3.000	0.000

(U) The BioComputational Systems (BioCOMP) component seeks to use computation to understand the complexity of biology, and in turn use biology to enhance methods of computation. The BioCOMP program will explore and develop computational models of bio-molecular processes in living cells that will enable a range of novel DoD capabilities for bio-agent threat assessment, force health protection, and bio-sensor design. In addition, the program will explore new biologically-inspired computing principles of robust information processing systems.

(U) A primary thrust of the BioCOMP program is the development of cutting edge computational models and tools for predictive systems biology and the demonstration of these tools in DoD applications. These computer prediction methods will give the warfighter more information about biological threats in far less time than today's costly wet-lab methods.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

(U) A critical challenge in the post-genomic era is the utilization of genomic information to model and characterize systems of bio-molecular networks and pathways underlying biological mechanisms at the cellular level. Models of complex gene-protein interactions will enable simulation, dynamic analysis, prediction and control of cellular processes. Based on these models, the program has developed Bio-SPICE (Simulation Program for Intra-Cell Evaluation), an open software framework providing innovative models and analysis tools. The extensible design of Bio-SPICE allows for adding, refining and customizing of the Bio-SPICE models and tools for specific cell processes.

(U) Technical challenges to developing Bio-SPICE are being met through the development of four-dimensional (4-D) computational models and simulation techniques, and by leveraging cognitive information processing tools. To transition the technology, the program is collaborating with several DoD client agencies including Defense Threat Reduction Agency (DTRA), U.S. Army Medical Research and Material Command (USAMRMC), Soldier Biological and Chemical Command (SBCCOM), Walter-Reed Army Institute for Research (WRAIR), Naval Medical Research Command (NMRC), the U. S. Air Force Toxicology program, and the Center for Disease Control and Prevention (CDC).

(U) Program Plans:

- Developed a progressively sophisticated suite of dynamic cellular models and architecture for Bio-SPICE which will enable modeling, prediction, and control of cellular processes. Continually validate results through experimentation.
- Incorporated spatial models into Bio-SPICE and explore potential reduced-order models to analyze the non-linear and stochastic dynamics of several hundred interactions.
- Built baseline models of intra-cell processes of interest to DoD, such as spore formation in bacteria like anthrax, bacterial cell division and growth, and cell death induced by toxins from bio-warfare agents (apoptosis). Identify candidate molecular targets for intervention strategies in sporulation (such as for therapeutics and safe decontamination), cell cycle control, and other processes in defense against bio-agents.
- Demonstrated computer analysis methods for commanders to use in the threat assessment of natural and emerging bio-agents. These methods, which predict pathogenicity and virulence of agents from their genomic information, were demonstrated for several bacterial pathogen cases (staphylococcal enterotoxin B [SEB], E coli), and resulted in far more information than today's costly wet-experiments.
- Identified new methods for early detection of exposure of soldiers to pathogens and toxins using molecular (gene expression) signatures, which is vital for early intervention and avoidance of death. These methods demonstrated a 95% accuracy rate in identifying exposure to host cells among a set of ten pathogens.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Develop a framework for describing and representing biological knowledge that spans data from the molecular (genomic, proteomic) to clinical level, and across organisms, to support deep and rapid knowledge extraction.
- Implement cutting edge learning and reasoning algorithms that act on vast amounts of biological, experimental and simulation data; and demonstrate rapid reasoning and knowledge-acquisition.

	FY 2005	FY 2006	FY 2007
Simulation of Bio-Molecular Microsystems (SIMBIOSYS)	5.160	5.000	0.000

(U) The Simulation of Bio-Molecular Microsystems (SIMBIOSYS) program is developing methods and tools to simulate and design Bio-Molecular Microsystems to dramatically improve the interaction and integration of biological elements with synthetic materials. This is being accomplished by exploring fundamental properties and compatibility of biological elements at the molecular surface level through experimental and theoretical analyses. Key phenomena under study 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 ratio [SNR] > 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 that, using microcantilevers, a nanoparticle conjugation can successfully enable detection of 10-100 atto-molar DNA concentrations with single base pair selectivity without performing polymerase chain reaction; transition to other DoD agencies and Homeland Defense.
- Demonstrate low power transport (~ 10X reduction in power) of fluids by modulating surface tension in droplet based transport.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Demonstrate surface-tension modulated transport of droplets on a substrate; demonstrate computational models to optimize transport characteristics.
- Demonstrate orders of magnitude (> 100X) improvement in microfluidic mixing using electrokinetic and Magneto Hydrodynamic (MHD) schemes (based on modeling studies).
- 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 2005	FY 2006	FY 2007
Bio Interfaces	4.000	3.500	8.500

(U) The Bio Interfaces program will support scientific study and experimentation, emphasizing the interfaces between biology and the physical and mathematical/computer sciences. This unique interaction will develop new mathematical and experimental tools for understanding biology in a way that will allow its application to a myriad of DoD problems. Chief among them is the ability to seamlessly integrate and control mechanical devices and sensors within a biological environment – a critical aspect in the successful implementation of a major prosthetics effort. In addition, these tools will help exploit the advances in the complex modeling of physical phenomena such as Electro-Magnetic Pulse (EMP) and blast with biological tissues and cells in order to understand and prevent the deleterious effects of traumatic brain injury. It is also expected that understanding the fundamentals of biology will aid in developing tools to understand complex, non-linear networks and force structures.

(U) Program Plans:

- Examine behavior of materials/biological interfaces to improve performance and biocompatibility of mechanical and microelectronic devices for ultimate integration into new prosthetic devices.
- Develop mathematical approaches and new microelectronic devices for sensing and controlling biological responses.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Develop predictive biologic models that take into account the materials and chemical properties of the brain to account for all blast effects including characteristics of the pressure wave, electromagnetic pulse, acoustics, etc.
- Demonstrate and validate novel mathematical tools for analyzing and interpreting complex data sets obtained from complex biological systems and behavior. Extend these tools to other problems of interest to DoD.
- Develop new mathematics that predicts fundamental biological processes across biological size and times scales.

	FY 2005	FY 2006	FY 2007
Biological Adaptation, Assembly and Manufacturing	11.200	9.000	12.500

(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. 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). In addition, the fault tolerance present in biological systems will be exploited in order to assemble and manufacture complex physical and multi-functional systems, both biological and abiotic. Further activity in this area will investigate the adaptability of the brain to information processing and situational awareness. Applications to Defense systems include the development of chemical and biological sensors, and improved battlefield survivability of the warfighter.

(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.
- Understand how cells and organisms can be adapted to respond to environmental chemicals and toxins of interest to DoD by producing signals (colors, fluorescence) that can be detected remotely.
- Understand how cells differentiate/heal into functional tissues using naturally occurring mechanisms and adapt these naturally occurring mechanisms to develop the ability to regenerate appropriate tissue and structure at a wound site rather than scarring.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Demonstrate the adaptation of bacteria to the digestion of cellulose in disaccharides to enable the ability to use fiber as nutrition and for the prevention of dysentery.
- Understand how the brain adapts to cognitive overload and develop novel methods for delivering information that can be more effectively processed by the brain.

	FY 2005	FY 2006	FY 2007
Nanostructure in Biology	10.382	10.042	13.266

(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. This new information about biomolecules will provide important new leads for the development of threat countermeasures, biomolecular sensors and motors, and molecular interventions to maintain human performance in the battlefield. This program will also develop approaches to mathematically predict a priori the structure of biological materials, especially proteins, based on the desired performance. This will enable the rapid design of new biosensors against previously unknown threats and the design of advanced catalysts based on biological activity to produce new materials of interest to DoD (e.g., tailored explosives). The program will also create technology to reliably integrate nanoscale and microsystems payloads on insects that will extract power, control locomotion, and also carry DoD relevant sensors. In addition, research will be conducted in the interaction, at the nanoscale, of biotic and abiotic materials and functions, a critical aspect in the development of advanced prosthetics.

(U) Program Plans:

- Investigate fundamental issues of nanowire communication with electrically active biological systems (neurons) including high density recording, information processing, stimulation patterns, and new computational methods of analysis.
- Demonstrate image formation through the use of microchip-driven wire to simultaneously stimulate thousands of retinal neurons.
- Use nanostructured neural interfaces to develop an understanding of the neural information and algorithms used for biological visual processing (e.g., object recognition).
- Demonstrate the ability to rapidly (hours as opposed to weeks or months) predict new protein structures that inactivate new biological pathogens or toxins.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Demonstrate approaches for making enzymes that catalyze chemical reactions not performed by natural enzymes for the synthesis of chemicals of interest to the Department of Defense.
- Demonstrate locomotion control of insects using MEMS platforms consisting of ultrasonic projectors, pheromone ejectors, insect mechano-sensor activation, and visual presentation manipulation, neural, or muscular interfaces.
- Demonstrate power scavenging from insects via thermal-to-electric, and/or mechanical-to-electrical power conversion using embedded micro power generators.

	FY 2005	FY 2006	FY 2007
Human Assisted Neural Devices	12.000	12.000	12.000

(U) This program will develop the scientific foundation for novel concepts that will improve performance on the battlefield as well as technologies for enhancing the quality of life of paralyzed veterans. This will require an understanding of neuroscience, 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. The science developed by this program will be exploited by the Revolutionizing Prosthetics program in PE 0602715E, Project MBT-02. Approaches for understanding the language of the brain will also be exploited to improve decision making in a variety of Defense applications including imagery analysis as well as understanding and improving cognitive performance under stress. Techniques will be examined to extract these signals non-invasively. This effort will be conducted with the Veteran's Administration to ensure approaches are compatible with prosthetic requirements.

(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, and other) from a peripheral device or interface that will provide critical inputs required for closed-loop control of a prosthetic.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01

- Explore new methods, processes, and instrumentation (e.g., Magnetoencephalography, optical, IR, and RF) for accessing neural codes non-invasively at appropriate spatiotemporal resolution to provide closed-loop control of a peripheral device.
- Identify robust neural signals that respond to visually salient objects and demonstrate that those neural signals can be used to significantly (3x) improve throughput in visual analysis tasks such as imagery analysis compared to using an individual's visuomotor transformation (i.e., movement) based response.
- Investigate the underlying mechanisms of perception and cognition and use these to develop optimal approaches to radically improve neural plasticity in soldiers under stressful operational conditions.

	FY 2005	FY 2006	FY 2007
Bio Detection of Unexploded Ordnance & Land Mines	1.900	0.000	0.000

(U) Continued to develop bee-based UXO detection as a viable technology for landmine detection. Research tasks focused on the development of a cost effective, reliable and easy-to-use bee detection system for the DoD, countermine, and homeland security communities.

	FY 2005	FY 2006	FY 2007
Biomedical Engineering Initiative	0.000	1.500	0.000

(U) Development of technologies to enable Biomedical Engineering.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE February 2006
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 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Information Sciences CCS-02	23.791	19.933	29.481	32.687	30.627	31.314	32.951

(U) Mission Description:

(U) This project supports scientific study and experimentation on new computational models and mechanisms for reasoning and communication in complex, interconnected systems in support of long-term national security requirements. The project is exploring novel means of exploiting computer capabilities; practical, logical and heuristic reasoning by machines; development of enhanced human-computer and computer-to-computer interaction technologies; innovative approaches to the composition of software; and new learning mechanisms for systematically upgrading and improving these capabilities. Promising techniques will transition to both ongoing and system-level projects.

(U) Program Accomplishments/Planned Programs:

	FY 2005	FY 2006	FY 2007
Computer Expoitation and Human Collaboration	23.791	19.933	22.908

(U) The Computer Exploitation and Human Collaboration program is developing highly innovative information processing technologies that will allow warfighters and commanders of the future to interact in a natural way with computers, enable a new generation of collaboration methods and information acquisition, and provide intelligent seamless exchange of information in a world where computing devices are ubiquitous and heterogeneous. The program is exploring new human-machine interaction (HMI) paradigms where computing and communications systems reason about warfighter's and commander's goals and capabilities, and use this information to drive the interaction. Technical challenges include architectures for software agents (including mobile code); redesign of classical computer operating systems; secure exchange of information over insecure channels; robust, natural modes for increasing information and knowledge; and organizing both into easily retrievable, re-usable forms. Research is addressing breakthrough techniques for distilling key concepts from massive amounts of information and novel information presentation modes to provide concise, salient situational awareness. Work includes creation of powerful multi-agent systems and tools for effective decision-making and analysis in complex, multi-participant environments; high-performance, user-centered interfaces capable of

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

understanding the warfighter and commander's combined natural communication and activity patterns; and fundamental technologies for integrating information expressed in different modalities and formats, which is currently a bottleneck to timely military situational awareness.

(U) The Computer Exploitation and Human Collaboration program is also exploring the fundamental science of interconnected systems to provide powerful mathematical tools for understanding the intrinsic properties and complexities of large-scale networks and other distributed systems. This foundational research is imperative for the future design of robust systems that break away from the established tradition of piece-meal patching of current infrastructures. The resulting mathematical tools will allow development and defense of critical infrastructures and create more efficient, reliable data networks for the warfighter. The security of the nation depends on interconnected systems, such as the power grid, telecommunications systems, social and organizational networks, economic and financial systems and command and control structures. These networks can suffer dramatic failures. Such failures can potentially be prevented or controlled through a fundamental, quantitative understanding of the intrinsic properties of networks. Deeper scientific foundations for what might be called "network understanding" will eventually generate dramatic new capabilities for the DoD while at the same time generating benefits for civilian applications. Overall, the research will provide vastly expanded power and improved interaction for a wide range of military tasks and environments.

(U) Research on machine intelligence over the last two decades has revealed that many reasoning problems are inherently computationally complex, and in many cases, intractable. Solutions to these problems typically require either enormous computer resources, or simplification of the problem resulting in major sacrifices to accuracy. The Real-World Reasoning thrust (REAL) is developing foundational technologies, heuristic approaches, and tools necessary to enable effective, practical machine reasoning about increasingly complex, large-scale problems on time scales and with accuracies that will aid commanders and warfighters in assessing the consequences of specific actions and strategies, and predict future results. This research will push the envelope of deep-reasoning decision making by systematically considering interactions among multiple teams of warfighters, robots and weapon systems in strategic settings where each team may have different or varying goals. The key technologies under investigation are effective, practical inferential reasoning in real-world situations with complexity and uncertainty; novel paradigms for learning from experience, events, and actions that affect the final outcome of a situation or scenario; integration of multiple reasoning paradigms; representation and reasoning with information that changes constantly over time; reasoning about the goals of other agents; pragmatic reasoning that uses appropriate default assumptions to respond intelligently; and appropriate metrics for measuring cognitive behavior and performance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) Program Plans:

- Developed new forms of human-computer interaction that enable humans and computers to work as synergistic teams. An initial suite of technologies have been developed and tested.
- Developed a mixed-initiative multi-threaded task manager that is able to be advised by the user, is able to alert the user to key activities and events, and is able to be told limited forms of new knowledge.
- Explored end-user models for integrating natural communication modalities (e.g., spoken language, gesture, and gaze) for a new class of interfaces. Preliminary work on spoken language input and gesture has been done and tested for robustness.
- Develop and evaluate initial suite of techniques for learning how to accomplish new unanticipated tasks and how to transfer and use knowledge from other domains.
- Develop innovative techniques for dramatically reducing the complexity and processing required for reaching conclusions in propositional logic systems.
- Continue to develop adaptive multimodal processing techniques tailored to the user, task, and environment, and assessing performance and usability advantages within multimodal systems.
- Establish multidisciplinary studies of large-scale interconnected systems drawn from the fields of information theory, complexity theory, adaptive systems, diffusion theory, group theory and social network analysis.
- Identify fundamental properties common across different types of networks and other distributed systems.
- Investigate the relationship between the statics and dynamics of networks, and relate these to important network operating parameters and properties (such as the resilience of networks to attacks and failures).
- Develop methods for combining statistical and knowledge-based reasoning and learning algorithms.
- Evaluated algorithms to find the dominant plan and/or the Nash equilibrium solution from a given set of plans for a variety of reasoning tasks, such as effective coalition formation.
- Develop strategic reasoning tools that aid decision-making in distributed environments, and systematically incorporate information, incentives and goals in a complex multi-adversarial environment.
- Develop and demonstrate scalable high-performance reasoning techniques and knowledge representation methods that perform temporal reasoning, handle rapid changes in information, and deal with temporal static uncertainty.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

	FY 2005	FY 2006	FY 2007
Computer Science Study Group	0.000	0.000	6.573

(U) The Computer Science Study Group (CSSG) program funds emerging ideas from the computer science academic community to address DoD's need for information exploitation technology; to educate young principal investigators; to acclimate a generation of researchers to the needs and priorities of the Department of Defense; and to enable the transition of those ideas and applications by promoting joint university, industry, and government projects. The CSSG project formalizes and focuses this research for efficiency and greater effectiveness.

(U) Program Plans:

- Establish a Computer Science Study Panel (CSSP) hosted by the Institute for Defense Analysis (IDA), consisting of mentors from senior academic and military communities.
- Arrange seminars for CSSP participants, at sites around the country where participants can experience DoD information exploitation capabilities and shortcomings.
- Evaluate and approve proposals for major university research projects to conduct basic information technology research, based on knowledge gained in CSSP meetings.
- Solicit co-funding from industry or interested government parties to continue successful university research projects.
- Develop transition strategy with university participants and co-funding sources.

(U) Other Program Funding Summary Cost:

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
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 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Electronic Sciences ES-01	33.815	30.783	34.060	30.853	30.752	31.752	31.752

(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 system and component level improvements to provide greater 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 may also offer new approaches to integration, testing, controlling, manipulating and manufacturing nanometer-scale structures, molecules and devices.

(U) Program Accomplishments/Planned Programs:

	FY 2005	FY 2006	FY 2007
University Photonic Opto-Centers	7.072	8.000	8.000

(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,

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

modulators and switches operating from infrared to ultraviolet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules. The University Photonic Opto-Centers Phase II 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. Commercially co-funded, industrial participants benefit by getting feedback from potential users of their device technology as well as by ensuring that the graduates are trained in the latest device technologies.

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

	FY 2005	FY 2006	FY 2007
Semiconductor Technology Focus Centers	10.000	10.000	10.000

(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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(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.
- 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 2005	FY 2006	FY 2007
Molecular Photonics(MORPH) (formerly Supermolecular Photonics Engineering)	6.893	7.885	2.610

(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 offers the potential for distinct electronic energy level engineering without the traditional semiconductor crystal lattice. This will allow more freedom to tailor electromagnetic responses 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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

- Address parameters such as 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.

	FY 2005	FY 2006	FY 2007
Photonics Technology Access Program (PTAP)	2.500	2.898	1.300

(U) The main goal of the Photonic Technology Access Program (PTAP) is to create a mechanism for providing the latest prototype optoelectronic devices and custom materials to systems researchers. The program seeks to build bridges between the device and systems research community, the university and industrial community and the teaching and research community.

	FY 2005	FY 2006	FY 2007
Carbon Nanotube RF Devices	0.000	0.000	3.000

(U) The goal of the Carbon Nanotube (CNT) Devices Program is to explore the feasibility of amplifying a specific type of single-walled CNT with increased efficiency. In addition, this program will create the ability to integrate CNT with conventional electrical device architectures and fabrication processes in a cost-efficient and technologically-relevant way, i.e., scaleable (automated), spatially addressable, and high yield.

(U) Program Plans:
- Develop techniques for the low-cost, mass production of a single-configuration CNTs (i.e., uniform armchair, zigzag or helical type).
- Develop integrated circuit devices such as field-effect transistors (FETs), high-Q, low loss RF filters, amplifiers and antenna for selected applications.
- Reduce the losses in electronic circuitry, which increases efficiency and lowers power consumption.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

	FY 2005	FY 2006	FY 2007
Quantum Entanglement Science and Technology (QuEST)	0.000	0.000	4.698

(U) The Quantum Entanglement Science and Technology (QuEST) program will explore the research necessary to create new technologies based on quantum information science. Technical challenges include loss of information due to quantum decoherence, limited communication distance due to signal attenuation, and protocols, and larger numbers of quantum bits (Qubits) and their entanglement. A key challenge is to integrate improved single and entangled photon and electron sources and detectors into quantum computation and communication networks. Error correction codes, fault tolerant schemes, and longer decoherence times will address the loss of information. Expected impacts include highly secure communications, algorithms for optimization in logistics, highly precise measurements of time and position on the earth and in space, and new image and signal processing methods for target tracking.

(U) Program Plans:
- Develop methods to mitigate loss of information due to decoherence.
- Develop techniques for rapid communication between non-adjacent qubits.
- Develop novel quantum algorithms.

	FY 2005	FY 2006	FY 2007
MEMS Science and Focus Centers	0.000	0.000	4.452

(U) The MEMS Science and Focus Centers effort is seeking research by means of multi-performer (university/nonprofit/industry/other) focus centers dedicated to advancing a number of core technologies considered essential to the advancement of MEMS and Nano-Electro-Mechanical Systems (NEMS) technology for applications important to the Department of Defense (DoD). The fundamental technology areas of interest for the program are: Surface Physics, Noise Mechanisms, Reliability Physics, Scaling Physics, Microfluidics, Interconnections, Single-Molecule Methods, Modeling, Signal Processing Methods, and other areas.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

	FY 2005	FY 2006	FY 2007
Advanced Photonics Research	3.500	0.000	0.000

(U) Program Plans:
- Continued research in photonic composites and device fabrication.

	FY 2005	FY 2006	FY 2007
Nanophotonics Systems Fabrication	2.850	0.000	0.000

(U) Program Plans:
- Enhanced nano-photonic systems fabrication capabilities for DoD by concentrating on unique technologies for photonic device fabrication, integration and packaging.

	FY 2005	FY 2006	FY 2007
Repeatable & Robust Lithographic Processes	1.000	0.000	0.000

(U) Program Plans:
- Developed novel lithographic devices and new processes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

	FY 2005	FY 2006	FY 2007
Infotonics Research	0.000	2.000	0.000

(U) Program Plans:
- Initiate research in Infotonics technology.

(U) Other Program Funding Summary Cost:

- Not Applicable.

THIS PAGE INTENTIONALLY LEFT BLANK

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE February 2006		
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 2005	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011
Materials Sciences MS-01	53.616	38.550	40.883	40.275	40.938	41.968	41.968

(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 2005	FY 2006	FY 2007
Nanoscale/Biomolecular and MetaMaterials	14.826	11.000	15.450

(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 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 and exploit the underlying dualities between discrete and continuous computational methods to dramatically improve DoD computational abilities.
- Apply ideas from non-Euclidean geometry to obtain fast optimization methods for certain problems in robotics, including pursuit-evasion, optimal path-planning, and reconfiguration.
- Explore fundamental behavior of nanostructured materials that display quantum and/or non-equilibrium behavior.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Develop theoretical advances to characterize the propagation of random effects through differential equation models of electromagnetic material systems to allow interpolation, extrapolation, and hybridization of solutions to known systems to closely related "perturbed" systems.
- 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.
- Demonstrate materials capability to allow multimodal imaging system with two orders of magnitude increased scan speed and detection for non-destructive testing and evaluation.
- Develop approaches for exploiting femtosecond laser pulses to generate multi-spectral imaging capable of examining nanostructured materials.
- Develop and exploit new mathematical principles including duality (transformation from an intractable to a tractable task), topology and non-Euclidean geometry to improve general computation capabilities, especially in solid state nanostructured materials.
- Exploit nanotechnology to create a new class of previously inaccessible compositions for optical materials, including IR windows and transparent armor.

	FY 2005	FY 2006	FY 2007
Engineered Bio-Molecular Nano-Devices and Systems	9.790	10.400	10.433

(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.

(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.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

– 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 2005	FY 2006	FY 2007
Spin Dependent Materials and Devices	6.000	12.000	15.000

(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. In addition, this program will examine other novel classes of materials such as plasmons or Bose-Einstein Condensates that have the potential to provide new capabilities in the quantum regime.

(U) Program Plans:

– Demonstrate a variety of spin related devices such as a room temperature spin light emitting diode (spin LED), a spin transistor with significant gain and magnetic random access memory scaled down into the few nanometer bit size by replacing magnetic field switching with spin momentum transfer switching.
– Develop new storage class memories with 100 – 1000 times the density of MRAM, DRAM or FLASH using magnetic domain walls as the storage media and spin momentum transfer as the read and write protocol.
– Investigate the magnetic and electronic characteristics of surface plasmons for the creation of metal/dielectric interfaces for coupling between photonic and electronic/spin states.
– Demonstrate atom-chip BEC lifetimes of >100ms and quasi-continuous BEC with 2000 atoms/pulse and >20% duty cycle.
– Demonstrate rotationally sensitive atom interferometer using optical readout in magnetic waveguides; establish sensitivity.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

	FY 2005	FY 2006	FY 2007
Spin Electronics	16.200	0.000	0.000

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

	FY 2005	FY 2006	FY 2007
Molecular Electronics	1.900	0.000	0.000

(U) Program Plans:
- Provided tools for developing molecular electronics technologies to enable construction of electronic circuits at the nanometer-scale for computation. Research focused on the simulation and direct-write fabrication of room temperature single electron transistors using focused ion beam instrumentation.

	FY 2005	FY 2006	FY 2007
Comparative Genomics for National Security Goals	3.000	1.500	0.000

(U) Program Plans:
- Develop new approaches to examine prognostic epidemiology using comparative genomics.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE February 2006
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

	FY 2005	FY 2006	FY 2007
Material Characterization and Meteorology Center	0.500	0.000	0.000

(U) Program Plans:
- Developed tools and methods for characterization of materials.

	FY 2005	FY 2006	FY 2007
Space Based Active Sensors	1.400	0.000	0.000

(U) Program Plans:
- Explored more efficient methods for the development of active sensors.

	FY 2005	FY 2006	FY 2007
Advanced Materials for Quantum Computing	0.000	2.650	0.000

(U) Program Plans:
- Development of materials that will enable the instantiation of quantum computing concepts.

	FY 2005	FY 2006	FY 2007
PBO	0.000	1.000	0.000

(U) Program Plans:
- Research into the application of PBO (Polyphenylene benzobisoxazole) in the development of non-flammable and lightweight materials.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 2004
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.