Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency										DATE: February 2012	
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*				R-1 ITEM NOMENCLATURE PE 0601101E: *DEFENSE RESEARCH SCIENCES*							
COST ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013 Base**	**FY 2013 OCO**	**FY 2013 Total**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**Cost To Complete**	**Total Cost**
Total Program Element	287.561	290.773	309.051	-	309.051	315.567	328.588	342.321	359.391	Continuing	Continuing
BLS-01: *BIO/INFO/MICRO SCIENCES*	47.799	35.009	39.678	-	39.678	36.125	36.248	37.248	40.925	Continuing	Continuing
CCS-02: *MATH AND COMPUTER SCIENCES*	52.560	59.492	67.601	-	67.601	68.342	68.412	73.812	76.451	Continuing	Continuing
CYS-01: *CYBER SCIENCES*	-	16.667	25.000	-	25.000	33.333	41.667	50.000	50.000	Continuing	Continuing
ES-01: *ELECTRONIC SCIENCES*	74.477	42.145	53.163	-	53.163	37.876	45.876	36.876	36.752	Continuing	Continuing
MS-01: *MATERIALS SCIENCES*	90.916	99.506	76.340	-	76.340	76.450	76.824	79.824	90.263	Continuing	Continuing
TRS-01: *TRANSFORMATIVE SCIENCES*	21.809	37.954	47.269	-	47.269	63.441	59.561	64.561	65.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

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, mathematical, computer, biological and materials sciences.

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 organism levels. Programs in this project also lay the groundwork for advances in military medicine and combat casualty care.

The Math and Computer Sciences project supports long term national security requirements through scientific research and experimentation in new computational models and mechanisms for reasoning and communication in complex, interconnected systems. The project is exploring novel means to exploit computer capabilities; enhance human-to-computer and computer-to-computer interaction technologies; advance innovative computer architectures; and discover new learning mechanisms and innovations in software composition. It is also fostering the computer science academic community to address the DoD's need for innovative computer and information science technologies. Additionally, this project explores the science of mathematics for potential defense applications.

The Cyber Sciences project supports long term national security requirements through scientific research and experimentation in cyber-security. Networked computing systems control virtually everything, from power plants and energy distribution, transportation systems, food and water distribution, financial systems, to defense

systems. Protecting the infrastructure on which these systems rely is a national security issue. The Cyber Sciences project will ensure DoD cyber-capabilities survive adversary attempts to degrade, disrupt, or deny military computing, communications, and networking systems. Basic research in cyber security is required to provide a basis for continuing progress in this area. Promising research results will transition to both technology development and system-level projects.

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.

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; and materials and measurements for molecular-scale electronics.

The Transformative Sciences project supports scientific research and analysis that leverages converging technological forces and transformational trends in the areas of computing and the computing-reliant subareas of social sciences, life sciences, manufacturing, and commerce as a means of improving military adaptation to sudden changes in requirements, threats, and emerging converging trends.

B. Program Change Summary ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	328.195	290.773	299.049	-	299.049
Current President's Budget	287.561	290.773	309.051	-	309.051
Total Adjustments	-40.634	-	10.002	-	10.002
• Congressional General Reductions	-1.503	-			
• Congressional Directed Reductions	-32.500	-			
• Congressional Rescissions	-3.821	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	4.800	-			
• SBIR/STTR Transfer	-7.610	-			
• TotalOtherAdjustments	-	-	10.002	-	10.002

Change Summary Explanation

FY 2011: Decrease reflects reductions for the Section 8117 Economic Adjustment, excessive growth, rescissions and the SBIR/STTR transfer offset by internal below threshold reprogrammings.
FY 2013: Increase reflects minor repricing.

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
BLS-01: *BIO/INFO/MICRO SCIENCES*	47.799	35.009	39.678	-	39.678	36.125	36.248	37.248	40.925	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Bio Interfaces	2.061	6.500	12.000

Description: The Bio Interfaces program supports 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. These tools will help exploit the advances in the complex modeling of physical and biological phenomena. It is also expected that understanding the fundamentals of biology will aid in developing tools to understand complex, non-linear networks and force structures. This program will also explore the fundamental nature of time in biology and medicine. This will include mapping basic clock circuitry in biological systems from the molecular level up through unique species level activities with a special emphasis on the applicability to human biology. Operational relevance of this research activity includes improving our understanding of sleep-wake cycles, increasing the scientific understanding of deployment cycle lengths, and enhancing our ability to model the dynamics of disease outbreaks.

FY 2011 Accomplishments:
- Applied scientific principles of mathematical decoding to elucidate the basis of temporal-spatial signatures within biological systems, particularly with respect to human biology.
- Compiled existing published techniques and approaches for deciphering temporal coding in genetic sequences and determined appropriateness of specific algorithms for elucidating periodic processes in DNA.

FY 2012 Plans:
- Identify and build a library of canonical episequence signatures that dictate spatio-temporal regulation of temporal processes using bioinformatic or data mining techniques as a stepping stone to understanding the nature of time in biology and medicine.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop in vitro or in vivo cellular systems in which clock components can be altered by environmental pressures, molecular biological techniques or perturbation with various stressors. - Synthesize the minimal set of episequence input data required for the creation of a predictive algorithm. ***FY 2013 Plans:*** - Validate the roles of the spatio-temporal components and signatures by creating experimental test platforms and assays that will stress and perturb the system to confirm contributions of temporal regulators. - Initiate the development of algorithms designed to predict pertinent time processes active in biological systems. - Refine temporal signature networks and libraries that dictate temporal process regulation for determination of minimal datasets necessary for validated models. - Develop and validate algorithms of temporal processes associated with developmental processes in prokaryotic and eukaryotic systems.			
Title: Biological Adaptation, Assembly and Manufacturing	11.088	6.509	8.000
Description: The Biological Adaptation, Assembly and Manufacturing program is examining the structure, function, and informational basis underlying biological system adaptation, 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 required for the military (such as blood, bioengineered tissues 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 (such as tissue constructs designed for reconstructive surgery). These systems include novel load-bearing bio-interactive materials and composites for repair of severe hard tissue trauma, including complex bone fractures. A key new antibody technology will develop the ideal antibody master molecule for use in unattended sensors that maintains high temperature stability and controllable affinity for threat agents. Using the Freytag triangle structure, the interplay of narratives or stories may reveal how they tap into an array of mechanisms implicated in memory, reasoning, and strategy behavior. Applications to Defense systems include the development of chemical and biological sensors; tools for strategic military decision-makers involved in public relations and information operations, and improved warfighter battlefield survivability. ***FY 2011 Accomplishments:*** - Designed and biomechanically tested fracture putty scaffolding design in ex vivo and in vivo large animal model of bone fracture. - Demonstrated the ability to produce an antibody with thermal stability from room temperature up to 70 degrees Celsius. - Demonstrated a 300-fold improvement in antibody binding affinity.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Provided samples of modified antibody molecules with enhanced affinity and stability to the Army's Edgewood Chemical Biological Center to conduct independent testing and evaluation for military biochemical sensor applications. - Initiated investigations into the relationship between dopaminergic-driven learning systems, hormones/neurotransmitters such as oxytocin, emotion-cognition interactions, and narrative structures. ***FY 2012 Plans:*** - Combine stability and affinity enhancements to produce "master antibodies" for testing in an existing biosensor platform to demonstrate advanced capability in terms of robustness and potential for multiplexing. - Explore and refine foundational assumptions on the utility of the Freytag structure ("setup-climax-resolution") for narrative analysis, including determining relationships between decomposed stories and neuropsychological mechanisms, and between narratives and behavior. - Develop decomposition frameworks and initial cluster of neurobiological mechanisms to better understand their relationship. - Develop tools to link analytic frameworks, neural mechanisms, and environmental variables to a particular story. ***FY 2013 Plans:*** - Develop sensor suite technologies based on neurobiological mechanisms to measure narrative effect on individuals/groups in real-time. - Study generalized findings in relation to distinct sub-groups to elucidate potential differences across varying cultures. - Employ newly developed narrative analysis tools, frameworks, and models to forecast narrative influence. - Initiate integration of program technologies.			
Title: Mathematics of the Brain (MoB) ***Description:*** The Mathematics of the Brain (MoB) program will develop a new mathematical paradigm for understanding how to model reasoning processes for application to a variety of emerging DoD challenges. The program will develop powerful new symbolic computational capabilities for the DoD in a mathematical system that provides the ability to understand complex and evolving tasks without exponentially increasing software and hardware requirements. This includes a comprehensive mathematical theory to exploit information in signals at multiple acquisition levels, which would fundamentally generalize compressive sensing for multi-dimensional sources beyond domains typically used. This program will establish a functional mathematical basis on which to build future advances in cognitive neuroscience, computing capability, and signal processing across the DoD. ***FY 2011 Accomplishments:*** - Developed aspects of a new compressive measurement theory intended to efficiently extract information from signals. - Explored the compressive measurement theory's utility in applications such as imaging and radar.	7.000	11.000	12.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Investigated novel forms of prior knowledge in order to improve sparse signal sampling. ***FY 2012 Plans:*** - Develop detailed mathematical prior-knowledge representations and associated models for imaging and radar applications. - Exploit the new theoretical measurement framework together with novel forms of prior knowledge in order to minimize resource requirements and maximize information gathering, from sparse sampling. - Demonstrate the utility of new compressive measurement theory via improvements in imaging and radar applications. ***FY 2013 Plans:*** - Identify fundamental bounds on performance and cost associated with linear and nonlinear signal priors. - Demonstrate novel reconstruction algorithms that incorporate both signal and task priors to enable improved reconstruction quality and/or reduced measurement resources. - Demonstrate visible imaging using 10x fewer measurements than reconstructed pixels. - Demonstrate RADAR imaging using 10x less bandwidth than a conventional non-compressive system. - Exploit the benefit of adaptation in order to achieve additional reductions in performance and/or measurement resources. - Exploit the benefit of information-optimal measurements within a signals intelligence application.			
Title: Physics in Biology ***Description:*** Understanding the fundamental physical phenomena that underlie biological processes and functions will provide new insight and unique opportunities for understanding biological properties and exploiting such phenomena. Physics in biology will explore the role and impact of quantum effects in biological processes and systems. This includes exploiting manifestly quantum mechanical effects that exist in biological systems at room temperature to develop a revolutionary new class of robust, compact, high sensitivity and high selectivity sensors. Investigation into quantitative neurophysics will examine new modalities for biological injury which could yield a new class of non-invasive medical imagers. ***FY 2011 Accomplishments:*** - Developed a quantum theory for the transport of excitons in photosynthetic systems and for magnetoreception in birds based on a radical pair mechanism. - Experimentally demonstrated coherent transport in a photosynthetic system at 277 K (ambient temperature). - Experimentally demonstrated that fruit flies can distinguish isotopic modification of odorant at room temperature, which is consistent with the predicted vibrational olfaction mechanism. - Developed new quantum process tomography technique for room temperature analysis of photosynthetic systems that is 1000x faster than current techniques.	9.000	11.000	7.678

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Developed broadband cavity-enhanced absorption spectroscopy technique for measurement of the response of the putative magnetoreceptor protein (cryptochrome) in the low-field (10 microT) regime. ***FY 2012 Plans:*** - Establish that magnetoreception is transduced through a biological quantum effect. - Develop concepts and designs for sensors inspired by biological quantum effects. - Experimentally probe the limits of biological sensors' exploitation of the quantum effects. - Demonstrate the biological and evolutionary advantage of quantum effects in photosynthetic systems. - Verify that molecular vibrations, and thus quantum effects, are essential to describing olfaction. ***FY 2013 Plans:*** - Model the performance of synthetic sensors that utilize quantum effects. - Demonstrate the improved performance of synthetic sensors that exploit biologically inspired quantum effects. - Demonstrate the ability to control quantum effects in biological systems by reorienting magnetoreception through the radical pair mechanism using radio frequency fields. - Develop a theory of olfaction that combines quantum and non-quantum effects.			
Title: Human Assisted Neural Devices - Medical ***Description:*** The Human Assisted Neural Devices program is developing the scientific foundation for understanding the language of the brain for application to a variety of emerging DoD challenges, including improving performance on the battlefield and returning active duty military to their units after injury. This requires an understanding of neuroscience, significant computational efforts, and new material design and implementation. Key advances expected from this research include determining the nature and means through which short-term memory is encoded, and discovering the mechanisms and dynamics underlying neural computation and reorganization. These advances will enable memory restoration through the use of devices programmed to bridge gaps in the injured brain. Further, modeling of the brain progresses to an unprecedented level with this novel approach. The programs funded under the Human Assisted Neural Devices are continued in Budget Activity 6.1 Medical Program Element 0601117E, in FY 2012 and subsequent years. ***FY 2011 Accomplishments:*** - Demonstrated improvement of memory retrieval accuracy and speed through use of patterned neural stimulation in animal studies. - Identified homogeneity of neural codes involving long-term memory in different animal models conducting similar memory tasks. - Modeled dynamic functional motor and sensory networks and developed methods for characterizing brain-wide sensory/motor tasks.	18.650	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Developed models that predict behavioral correlates of neural activity, based on neural firing patterns that occur prior to onset of the behavioral output. - Investigated stimulation of sensory networks to determine how sensory information is encoded and utilized by the brain. - Developed models of neural activity that more accurately reflect multi-scale biological signaling. - Fabricated neural interfaces capable of stimulating and recording multiple channels of neural activity at distributed sites throughout the brain. - Developed new methods and tools that enable selective neuromodulation of specific types of neurons.			
Accomplishments/Planned Programs Subtotals	47.799	35.009	39.678

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
CCS-02: *MATH AND COMPUTER SCIENCES*	52.560	59.492	67.601	-	67.601	68.342	68.412	73.812	76.451	Continuing	Continuing

A. Mission Description and Budget Item Justification

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-to-computer and computer-to-computer interaction technologies; innovative approaches to the composition of software; innovative computer architectures; and new learning mechanisms for systematically upgrading and improving these capabilities. Additionally, this project explores mathematical programs and their potential for defense applications. Promising techniques will transition to both technology development and system-level projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Computer Science Study Group (CSSG)	9.415	12.000	5.100

Description: The Computer Science Study Group (CSSG) program supports emerging ideas from the computer science academic community to address the DoD's need for innovative computer and information science technologies; introduces a generation of junior researchers to the needs and priorities of the DoD; and enables 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.

FY 2011 Accomplishments:
- Selected thirteen promising computer scientists to form the Class of 2011.
- Awarded grants to ten Principle Investigators (PIs) from the Class of 2010 in support of research with high payoff potential to DoD.
- Initiated transition of research from CSSG PIs to several defense and intelligence organizations (i.e., PEO-Soldier Army Research, Development, and Engineering Command (RDECOM), Office of the Director of National Intelligence, Defense Intelligence Agency, and Army Research Office).

FY 2012 Plans:
- Transition successful research outcomes from Classes 2008-2011.
- Award grants to at least nine PIs from the Class of 2011 in support of research with high payoff potential to DoD.
- Award grants to at least three PIs from Class of 2009 who successfully transition their research into partnerships with other sources of funding from government or industry.

FY 2013 Plans:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Transition successful research outcomes from Classes 2009-2011. - Award grants to at least three PIs from Class of 2010 who successfully transition their research into partnerships with other sources of funding from government or industry.			
Title: Young Faculty Award (YFA)	11.413	13.000	13.000
Description: The goal of the Young Faculty Award (YFA) program is to encourage new faculty members at academic institutions to participate in sponsored research programs that will augment capabilities for future defense systems. This program focuses on speculative technologies for greatly enhancing microsystems technologies, innovative information technologies, and defense sciences. The long-term goal for this program is to develop the next generation of academic scientists, engineers, and mathematicians in key disciplines who will focus a significant portion of their careers on DoD and National Security issues. Current activities include research in twelve topic areas: Quantum Science and Technology; New Physical Methods for Biological Characterization and Control; Mathematics; Structural Materials; Functional Materials; Power and Energy; Advanced Electronics; Micro/Nano Electro-Mechanical Systems (MEMS/NEMS); Photonics and Lasers; Digital Direct Manufacturing; Neuroscience; and Computational and Quantitative Social, Decision, and Behavioral Sciences. For YFA 2012 a new topic on Robotics will be added and the three historic materials science and power & energy topics will be replaced with three revised materials science topics. A key aspect of the YFA program is DARPA-sponsored military visits; all YFA Principal Investigators are expected to participate in one or more military site visits to help them better understand DoD needs. ***FY 2011 Accomplishments:*** - Exercised for thirty-three FY 2010 awardees second year options to continue research focused on new concepts for microsystem technologies, innovative information technologies, and defense sciences. - YFA investigators participated in military and DoD site visits to further their education on DoD needs and encourage focus of future work in multiple research areas. - Awarded thirty-nine new grants for the FY 2011 class in the following topic areas: Quantum Science and Technology (4); New Physical Methods for Biological Characterization and Control (5); Mathematics (3); Structural Materials (2); Functional Materials (4); Power and Energy (4); Advanced Electronics (4); Micro/Nano Electro-Mechanical Systems (MEMS and NEMS) (4); Photonics and Lasers (4); Digital Direct Manufacturing (1); Neuroscience (2); and Computational and Quantitative Social, Decision, and Behavioral Sciences (2). - Continued a mentorship component to the program to educate the academic performers on DoD needs and encourage focus of future work in this area. ***FY 2012 Plans:*** - Exercise second year options for selected FY 2011 participants to continue research focused on new concepts for microsystem technologies, innovative information technologies, and defense sciences. - Award FY 2012 grants for new two-year research efforts across the topic areas.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Establish approaches to bring appropriate technologies developed through YFA to bear on relevant DoD problems. - Continue mentorship by program managers and engagement with DARPA to encourage future work focused on DoD needs. ***FY 2013 Plans:*** - Exercise second year options for FY2012 participants to continue research focused on new concepts for microsystem technologies, innovative information technologies, and defense sciences. - Award FY 2013 grants for new two-year research efforts across the topic areas. - Establish approaches to bring appropriate technologies developed through YFA to bear on relevant DoD problems. - Continue mentorship by program managers and engagement with DARPA to encourage future work focused on DoD needs.			
Title: Strategic Social Interaction Modules (SSIM) ***Description:*** The Strategic Social Interaction Modules (SSIM) program will improve military training to include the social interaction skills and abilities warfighters need for successful engagement with local populations. In the current operational environment, it is imperative to develop rapport with local leaders and civilians as their cooperation and consent will be necessary for successful operations. SSIM will emphasize the foundational social skills necessary to achieve cultural understanding in any social setting and the skills necessary for successful interactions across different social groups. These core skills do not require soldiers to have knowledge of a specific culture prior to contact but emphasizes skills for orienting toward and discovering patterns of meaningful social behavior. SSIM will develop the requisite training technology including advanced gaming/simulation techniques that incorporate new methods for practicing social agility in social encounters, as well as how to discover and adapt to unfamiliar culturally-specific conduct, manners, and practices. SSIM will enhance military effectiveness by enabling close collaborative relationships with local peoples and leaders. ***FY 2011 Accomplishments:*** - Performed scientifically-based observational studies of social interaction skills and associated human proficiencies exercised by successful practitioners in potentially hostile social engagements. - Began design and development of technologies for a training simulator that will exercise social interaction skills while performing military tasks. - Conducted an early demonstration of a tool for quantitative evaluation of social performance in groups. ***FY 2012 Plans:*** - Increase the robustness of training simulator technologies that will generate realistic training scenarios and user challenges, automate the evaluation of user responses, and support the semi-automated expert authoring/editing of scenarios. - Deploy initial training simulators to potential transition partners such as the U.S. Marine Corps and the U.S. Army. - Extend the intelligence of the non-player-characters and the training scenarios that the trainee must handle to include engagements with transitions to and from kinetic actions.	6.854	10.700	14.101

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop techniques for assessment of trainee learning during game play. - Develop social media curricula for computer-based training. ***FY 2013 Plans:*** - Gather observational data of the effectiveness of SSIM trained warfighters. - Test accuracy of non-player-character reactions to trainee's actions and behaviors. - Develop statistical methods to evaluate the effectiveness of training warfighters to exercise skillful interpersonal interactions with local populations while performing military tasks.			
Title: Engage ***Description:*** The Engage program develops problem-solving games in science, technology, engineering, and mathematics (STEM) to teach problem solving in complex real-world settings not amenable to conventional curriculum-based approaches. The focus is on problem-solving and combined human-computer reasoning on complex problems that provide users with immediate feedback and alternative solutions. Engage will also address the difficult problem of assessing performance in the virtual domain to predict performance in the real world and drive the creation of more effective game-based training. ***FY 2011 Accomplishments:*** - Explored game and problem-solving-based approaches to learning in complex real-world domains. - Developed approaches for extrapolating performance on computer-based training systems to performance in the real world. - Developed an award winning math game that teaches fractions ("Refractions") and made it available to users via the World Wide Web. ***FY 2012 Plans:*** - Develop software infrastructure for an educational gaming environment that allows the methods of instruction to be varied in order to determine the best approaches. - Analyze educational methodologies using statistics based on data drawn from a large video game environment. - Develop and release Engage-based games for teaching additional core STEM topics. ***FY 2013 Plans:*** - Improve the problem-solving-game platform based on the initial research results. - Re-implement the various application domain games using the improved platform. - Analyze and assess changes to existing Engage-based games when applied to different student age groups. - Develop and release Engage-based games for teaching additional core STEM topics. - Transition first phase of Engage-based games to DoD Education Activity (DODEA) schools.	6.600	7.000	9.400
Title: Mathematics of Sensing, Exploitation and Evaluation (MSEE)	3.000	8.000	11.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Mathematics of Sensing, Exploitation and Evaluation (MSEE) program is an outgrowth of the Focus Areas in Theoretical Mathematics program that seeks to create a comprehensive mathematical theory of information processing, strategy formulation and decision determination. Such a theory would incorporate techniques from diverse mathematical disciplines such as Stochastic Process Theory, Harmonic Analysis, Formal Languages and Theoretical Computer Science to construct a common framework wherein the quantitative value of data acquisition may be assessed relative to dynamically-varying context. In addition, the structure will accommodate the notion that data acquisition and information processing are coupled, requiring some degree of feedback and control, while simultaneously admitting the possibility of different logics, such as those that allow for incomplete and time-varying states of knowledge. The result of this effort will produce advances in fundamental domains of mathematics with the potential to reshape current DoD approaches to managing the battlespace. ***FY 2011 Accomplishments:*** - Mathematically formalized the notions of information processing, strategizing and decision determination to be modeled as a computational process. - Began investigation into methods for constructing relevant models of DoD-relevant environments, and developed effective strategies for updating these as new information becomes available. ***FY 2012 Plans:*** - Incorporate stochastic models and statistical reasoning to understand the nature of computations in human minds. - Explore open system concepts capable of demonstrating the ability to process information and determine best available responses, subject to time-varying context. - Begin to quantify notion of effective utility, which measures the relative value of a sensor or sensor system. ***FY 2013 Plans:*** - Refine representation objects to incorporate additional capabilities, such as variable exploitation or execution tasks. - Expand mathematical framework to allow incorporation of multiple sensing modalities, in particular, video. - Perform initial testing and validation; formulate and calculate performance metrics that quantify expected performance gains. - Design and prototype algorithmic system architecture that ensures flexibility and extensibility; begin creation of modular open system. - Implement single-modality solution that will demonstrate effectiveness of unified approach to sensing and will incorporate prior work on representations. - Formulate design, analysis, and testing of new systems in a way that incorporates stochasticity and uncertainty intrinsically. - Quantitatively demonstrate the benefits (both in terms of actual cost savings as well as increase in reliability and safety) that will accrue by adopting probabilistic methods.			
Title: Graph-theoretical Research in Algorithm Performance & Hardware for Social networks (GRAPHS)*	-	8.792	10.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: *Formerly Math for Social Networks While the DoD has been extremely effective in deploying rigorous analytical and predictive methods for problems involving continuously valued variables (tracking, signals processing), analytical methods for discrete data such as graphs and networks have not kept pace. Recent evidence has shown that social network analysis can provide critical insight when used in DoD-relevant scenarios. In this paradigm, nodes represent people of interest and their relationships or interactions are edges; the result forms a network or graph. Current analysis of social networks, however, is just in its infancy: the composition of real-world networks is understood only at the most coarse and basic details (diameter, degree distribution). In order to implement social network techniques efficiently and usefully, a better understanding of the finer mathematical structure of social networks is needed. This includes the development of a comprehensive and minimal mathematical set which characterizes social networks of DoD interest, and includes a description of how these quantities vary in both space and time. This also necessitates creation of fundamental theory of how heterogeneous social networks of different media (Facebook, Twitter, Picasa) interact. ***FY 2012 Plans:*** - Create an enhanced network modeling theory that incorporates ability to perform spatiotemporal analysis. - Investigate impact of replacing generic network nodes with human agents whose behavior can be modeled statistically. - Perform small-scale analyses of dynamic networks and demonstrate ability to recognize event precursors. - Identify relevant graph classes for DoD applications and characterize complexity classes of networks that are amenable to approximate algorithm development. ***FY 2013 Plans:*** - Derive analytic models for commonly occurring social network configurations such as call graphs. - Characterize normalcy and anomaly in structural signal constituents and formulate a detection methodology that incorporates novel noise models. - Develop Efficient Polynomial Time Approximation Schemes (EPTAS) for relevant graph algorithms and classes and proofs delineating for which classes and algorithms EPTAs are constructible. - Test modeling and detection methods against existing corpi and evaluate effectiveness. - Develop prototype of a multi-node, customized system leveraging existing hardware that realizes 10x performance time improvement in the current state of the art.			
Title: Unconventional Computation	-	-	5.000
Description: The Unconventional Computation program is a broad-based effort to develop new methods of computing by investigating, exploiting, and advancing novel computation models - such as those found in neuro-biological systems - that are currently unavailable in conventional microprocessors and can theoretically boost processing efficiency by three orders of			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
magnitude for certain important classes of DoD-critical applications. The program will require cross-disciplinary collaboration to exploit and advance unique computational models and connectivity architectures which minimize power, processing time, and/or instruction complexity in DoD-critical applications such as image/pattern detection, signal filtering/data reduction, and change detection. Some example approaches include, but are not limited to, co-opting neuro-biological material to implement a specific function or mapping biological functions to electronic circuitry. Bayesian inference engines, specialized processors, approximate computation, and DNA computing are explicitly of interest. The ultimate goal of the Unconventional Computing program is to develop devices, architectures, and systems capable of exploiting innovative computation models to enhance the computation capabilities of the DoD. ***FY 2013 Plans:*** - Explore and evaluate candidate computational models which can facilitate superior processing efficiency and performance for certain classes of applications. - Develop fundamental device and architecture concepts for exploiting new computational models. - Develop methods to program and maintain data integrity using novel computational models.			
Title: Foundational Machine Intelligence ***Description:*** The Foundational Machine Intelligence program supported research on the foundations of artificial intelligence and machine learning and reasoning. One focus was on techniques that can efficiently process and "understand" massive data streams. Deeply layered machine learning engines were created that use a single set of methods in multiple layers (at least three internally) to generate progressively more sophisticated representations of patterns, invariants, and correlations from data inputs. These will have far-reaching military implications with potential applications such as anomaly detection, object recognition, language understanding, information retrieval, pattern recognition, robotic task learning and automatic metadata extraction from video streams, sensor data, and multi-media objects. Foundational Machine Intelligence also examined the human aspects of computing, with interest in collaboration, interaction and information exchange; non-symbolic representation/reasoning paradigms based upon a universal "cortical" algorithm; and modeling of human language acquisition by associating words with the real-world entities perceived through multiple modes of sensory input. ***FY 2011 Accomplishments:*** - Created parameter-free methods that learn appropriate representations starting from raw inputs with a single architecture and learning algorithm. - Enabled machines to incorporate sensory information in a robust way to improve situational awareness. - Extended sub-symbolic learning algorithms to work with richer, non-linguistic input and knowledge representations.	5.000	-	-
Title: Information Theory for Wireless Mobile Ad Hoc Networks (ITMANET)	2.215	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Information Theory for Wireless Mobile Ad Hoc Networks (ITMANET) program created an information theory for ad hoc mobile wireless networking in the absence of wired infrastructure. Issues addressed included quantifying network performance in terms of throughput, delay, reliability, and other critical parameters as a function of node mobility, network topology, channel access protocol, bandwidth efficiency, and the overhead incurred through the exchange of channel and network state information. The revolutionary new and powerful information theory developed under ITMANET will enable the next generation of DoD wireless networks and provide insight concerning the acquisition and deployment of nearer-term systems. ***FY 2011 Accomplishments:*** - Predicted performance in terms of throughput-delay-reliability for many MANET realizations. - Developed protocols for interference alignment architectures that can approach the end-to-end MANET transmission capacity limit for many advanced MANET realizations. - Developed a generalized theory of rate distortion and network utilization that can lead to an optimal and adaptive interface between networks and applications that results in maximum performance regions.			
Title: Computer Science /Science, Technology, Engineering, and Mathematics Research Outreach ***Description:*** The Computer Science, Science, Technology, Engineering, and Mathematics Research Outreach program developed educational practices and programs that captured the scientific and technical interests of middle and high school students through compelling projects that require computer science, science, technology, engineering, and mathematics. ***FY 2011 Accomplishments:*** - Developed and released CS-STEM web-based games and virtual environments for teaching computer programming skills.	5.000	-	-
Title: Focus Areas in Theoretical Mathematics (FAThM) ***Description:*** The Focus Areas in Theoretical Mathematics (FAThM) program fostered major theoretical breakthroughs in pure mathematics whose potential for long-term defense implications was high. By supporting closely integrated and concentrated collaborations among small numbers of leading experts, FAThM explored a new approach for conducting focused research to explore fundamental interconnections between key areas of mathematics where critical insights should lead to both new mathematics and innovative DoD applications. ***FY 2011 Accomplishments:*** - Established and exploited new relations between differential geometry, quantum field theories, and infinite dimensional global analysis. - Established and exploited new relations between generalized homology theories and partial differential equations.	1.350	-	-
Title: 23 Mathematical Challenges	1.713	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: This program aimed to revolutionize the mathematical tools used by DoD in both theory and applications, discover and generate powerful and innovative new mathematics, tackle long-standing mathematical problems, and create new mathematical disciplines to meet the long-term needs of the DoD across diverse scientific and technological areas. ***FY 2011 Accomplishments:*** - Extended known links (e.g., de Rahm-Witt complexes and K-groups) between topology and algebra for continuous manifolds to the case of discrete structures. - Improved understanding of differential equations appearing in number theory, as a tool for passing between number theory and geometry.			
Accomplishments/Planned Programs Subtotals	52.560	59.492	67.601

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
CYS-01: *CYBER SCIENCES*	-	16.667	25.000	-	25.000	33.333	41.667	50.000	50.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Cyber Sciences project supports long term national security requirements through scientific research and experimentation in cyber-security. Networked computing systems control virtually everything, from power plants and energy distribution grids, transportation systems, food and water distribution systems, and financial networks to defense systems. Protecting the infrastructure on which these systems rely is a national security issue. Cyberspace is not only critical to our national security, it is fundamental to our way of life: over the past decade information technologies have driven the productivity gains essential to U.S. economic competitiveness. Unfortunately, during the same period, cyber-adversaries, which include nation-states, criminal/terrorist groups, transnational actors, and miscreants, have grown rapidly in sophistication and number. The Cyber Sciences project will ensure DoD cyber-capabilities survive adversary attempts to degrade, disrupt, or deny military computing, communications, and networking systems. Basic research in cyber security is required to provide a basis for continuing progress in this area. Promising research results will transition to both technology development and system-level projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Active Authentication*	-	5.500	10.200
Description: * Formerly Risk-Managed Access Control The Active Authentication program will develop more effective user identification and authentication technologies. Current authentication approaches are typically based on long, complex passwords and incorporate no mechanism to verify the user originally authenticated is the user still in control of the session. The Active Authentication program will address these issues by focusing on the unique aspects of the individual (i.e., the cognitive fingerprint) through the use of software-based biometrics that continuously validate the identity of the user. Active Authentication will integrate multiple biometric modalities to create a system that is accurate, robust, and transparent to the user. ***FY 2012 Plans:*** - Conceptualize methods for determining user identity that minimize user interruption. - Implement software biometric approaches that integrate cognitive features such as use of the mouse and the use of written language in an e-mail or document. - Formulate new access control mechanisms that incorporate a probabilistic measure of user identity. ***FY 2013 Plans:*** - Develop open application programming interfaces to allow the ready integration of software and hardware biometrics independent of origin. - Develop and demonstrate a new authentication platform suitable for deployment on DoD platforms.			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Implement multiple advanced authentication mechanisms in one or more prototype systems.			
Title: Automated Program Analysis for Cybersecurity (APAC)* ***Description:*** *Formerly Cross-Layer Network Security Automated Program Analysis for Cybersecurity (APAC) is developing automated program analysis techniques for mathematically validating the security properties of mobile applications. This will involve creating new and improved type-based analysis, abstract interpretation, and flow-based analysis methods with a far greater ability to accurately demonstrate security properties without false alarms than is possible today. APAC technologies will enable developers and analysts to identify mobile applications that contain hidden malicious functionality and bar those applications from DoD mobile application marketplaces. ***FY 2012 Plans:*** - Define a collection of specific security properties that demonstrate a mobile application is not malicious. - Develop automated program analysis techniques for determining whether or not mobile applications have specific security properties and implement these techniques in prototype tools. - Extract relevant classes of malicious techniques from publicly available malware. ***FY 2013 Plans:*** - Commence periodic red team engagements to challenge the capabilities incorporated in prototype tools. - Use these adversarial engagements to drive the development of increasingly effective prototype tools and specific properties. - Measure the effectiveness of the prototype tools and specific properties against the program metrics: false alarm rate, missed detection rate, and amount of manual effort required to certify a typical mobile application.	-	11.167	14.800
Accomplishments/Planned Programs Subtotals	-	16.667	25.000

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

TBD

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
ES-01: *ELECTRONIC SCIENCES*	74.477	42.145	53.163	-	53.163	37.876	45.876	36.876	36.752	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Optical Radiation Cooling and Heating in Integrated Devices (ORCHID)	5.263	2.653	7.750

Description: Many Department of Defense (DoD) systems use micro- and nano-electromechanical systems (MEMS and NEMS). These devices are used in compact accelerometers and gyroscopes for stability control in inertial navigation and in switches for optical communication and data routing. These devices operate many orders of magnitude away from their ultimate limits. Techniques to reduce or overcome thermal noise in MEMS/NEMS devices are critical for realizing their full potential.

Opto-mechanical devices offer a novel, noncryogenic path toward sensing at the standard quantum limit (SQL). Ultimately, quantum (shot) noise limits the performance of many sensitive optical instruments including force sensors, trace gas detectors, and laser gyroscopes. However, opto-mechanical devices can also control the quantum fluctuations of optical probes to reduce readout sensitivity below SQL, via a technique known as squeezing.

The ORCHID program will leverage recent successes within the field of cavity-opto-mechanics to broadly explore the application space while driving technological development toward smaller and more robust devices capable of deployment in the field. It is envisioned that such devices, once demonstrated, will find broad application across DoD, particularly in the areas of force sensing and optical communication.

FY 2011 Accomplishments:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated devices with a cavity finesse of 10^5, an effective mass of less than 1 nanogram, resonant frequencies larger than 100 megahertz and mechanical quality factors of up to 10^7; these parameters are necessary to reach the quantum ground state of mechanical motion thus enabling high sensitivity and high bandwidth accelerometers. - Demonstrated a microwave oscillator with a phase noise of -135 decibels relative to carrier at 100 kilohertz offset from a 235 megahertz carrier signal, a record low phase noise of opto-electronic-oscillators. This is constructive progress towards applying optomechanical microwave oscillators in modern communications, multi-static radar and precision time keeping systems. - Demonstrated a record-breaking on-chip opto-mechanical optical delay line of up to 50 ns. Such on-chip delays are useful for implementing optical storage for data synchronization, small optical switches and efficient non-linear devices for lasers, amplifiers, detectors, modulators and wavelength converters. - Built first generation of opto-mechanical devices such as tunable directional couplers and mechanical memories. ***FY 2012 Plans:*** - Demonstrate a low phase noise opto-mechanical oscillator with frequency greater than 10 gigahertz; a frequency compatible for modern communication and radar systems. - Demonstrate an optical switch with switching time less than 100 nanoseconds (ns) for enhanced on-chip data processing. - Demonstrate an opto-mechanical mass sensor with 10 zeptogram sensitivity in air for molecular identification in atmospheric conditions. - Demonstrate quantum state transfer between optical and motional states for optical wavelength conversion and long distance transport of information. ***FY 2013 Plans:*** - Demonstrate an opto-mechanical mass sensor with 1 zeptogram sensitivity in air for single atom identification under atmospheric conditions. - Demonstrate an optical switch with switch time less than 10 nanoseconds for high-speed on-chip optical data processing. - Build an on-chip opto-mechanical oscillator at 11 gigahertz with a phase noise below -120 decibels relative to carrier/hertz at 100 kilohertz offset, more than 100 megahertz of continuous tunability and 2.5 gigahertz of discrete tunability. - Demonstrate the conversion of microwave phonons to optical photons for optical wavelength conversion and long distance transport of information.			
Title: Advanced X-Ray Integrated Sources (AXIS)	-	5.000	11.000
Description: The objective of the Advanced X-Ray Integrated Sources (AXIS) program is to develop tunable mono-energetic X-ray sources that are spatially coherent with greatly reduced size, weight and power while dramatically increasing their electrical efficiency through application of micro-scale engineering technologies such as MEMS and NEMS. Such X-ray sources will enable new versatile imaging modalities based on phase contrast which are 1000X more sensitive than the conventional absorption contrast imaging. Such imaging modalities should enable reverse engineering of integrated circuits to validate trustworthiness			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
as well as battlefield imaging of soft tissues and blood vessel injuries without the injection of a contrast enhancing agent in blunt trauma. It will also reduce radiation dose required for imaging. The Basic Research component of this effort will focus on defining the fundamental science necessary for the creation of compact and highly efficient synchrotron X-ray sources. These sources may lead to future developments in the tunable imaging field. This program also has related applied research efforts funded under PE 0602716E, Project ELT-01. ***FY 2012 Plans:*** - Establish physical limitations for designing enabling components and compact energy-efficient X-ray sources. - Investigate fundamental issues pertinent to generation of coherent x-rays through emittance exchange and Inverse Compton Scattering (ICS), and through optically driven acceleration and free electron lasing. - Develop a Laser Wakefield Plasma electron accelerator and demonstrate the ability to produce X-rays from Betatron oscillations. - Develop and demonstrate a novel approach to high-performance cathode design and fabrication. - Develop and demonstrate the viability of pyroelectric-based next-generation electron emitters. ***FY 2013 Plans:*** - Fabricate and demonstrate arrays of closely spaced electron sources with short pulse duration and low emittance. - Fabricate and demonstrate free space acceleration of electrons using high finesse optical cavities and dielectric structures. - Fabricate and demonstrate the feasibility and viability of generating x-rays through channeling radiation.			
Title: Diverse & Accessible Heterogeneous Integration (DAHI) ***Description:*** Prior DARPA efforts have demonstrated the ability to monolithically integrate inherently different semiconductor types to achieve near-ideal "mix-and-match" capability for DoD circuit designers. Specifically, the Compound Semiconductor Materials On Silicon (COSMOS) program, in which transistors of Indium Phosphide (InP) can be freely mixed with silicon complementary metal-oxide semiconductor (CMOS) circuits to obtain the benefits of both technologies (very high speed and very high circuit complexity/density, respectively). The Diverse & Accessible Heterogeneous Integration (DAHI) effort will take this capability to the next level, ultimately offering the seamless co-integration of a variety of semiconductor devices (e.g., GaN, InP, GaAs, ABCS), microelectromechanical (MEMS) sensors and actuators, photonic devices (e.g., lasers, photo-detectors) and thermal management structures. This capability will revolutionize our ability to build true "systems on a chip" (SoCs) and allow dramatic size, weight and volume reductions for a wide array of system applications.	-	7.000	10.495

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
The Basic Research part of this program will focus on the development of new hetero-integration processes and capabilities that, if successful, will ultimately be demonstrated in application-specific circuits and transferred into the manufacturing flow. Applied research efforts are funded in PE 0602716E, Project ELT-01. ***FY 2012 Plans:*** - Explore heterogeneous integration of novel, emerging materials and devices. - Develop new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices. ***FY 2013 Plans:*** - Continue to explore heterogeneous integration of novel, emerging materials and devices. - Continue to develop new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices, and initiate transition of these processes to foundry fabrication flows under development in the applied research effort under DAHI.			
Title: Microscale Plasma Devices (MPD) ***Description:*** The goal of the Microscale Plasma Devices (MPD) program is to design, develop, and characterize MPD technologies, circuits, and substrates. The MPD program will focus on development of fast, small, reliable, carrier dense, microplasma switches capable of operating in extreme conditions, such as high-radiation and high-temperature environments. Specific focus will be given to methods that produce efficient generation of ions, radio frequency energy, and light sources over a range of gas pressures. Applications for such devices are far reaching, including the construction of complete high-frequency plasma-based logic circuits, and integrated circuits with superior resistance to radiation and extreme temperature environments. It is envisaged that both two and multi-terminal devices consisting of various architectures will be developed and optimized under the scope of this program. MPDs will be developed in various circuits and substrates to demonstrate the efficacy of different approaches. The Basic Research part of this effort is focused on fundamental MPD research and will advance scientific knowledge based on the study of several key MPD design parameters. These parameters include ultra-high pressure and carrier densities regimes. MPD will focus on expanding the design space for plasma devices enabling revolutionary advances in microplasma device performance. It is expected that MPD will develop innovative concepts and technologies that are clearly disruptive with respect to the current state of the art. Fundamental scientific knowledge derived from MPD is also expected to drive developments in commercialization of MPD technology developed and funded in PE 0602716E, Project ELT-01. ***FY 2012 Plans:*** - Define device architecture and design parameters.	-	2.000	3.918

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Investigate plasma generation at ultra-high (1-20 atmosphere) pressures. - Study plasma with carrier density exceeding 1E18/cubic centimeter. - Investigate effects of high-temperature environments on plasma generation (up to 600 degrees Celsius). - Study plasma generation in 1-20 micrometer scale microcavities. - Investigate microcavity uniformity and geometry necessary for 100 picosecond MPD switching speeds needed for robust survivability in high power electromagnetic fields. ***FY 2013 Plans:*** - Optimize environmental conditions for plasma generation at ultra-high (1-20 atm) pressures. - Improve robustness of plasma devices with carrier density exceeding 1E18/cubic centimeter. - Characterize MPD device reliability in extreme radiation environments. - Continue to investigate effects of high temperature environments on plasma generation (up to 600 degrees Celsius). - Refine microcavity uniformity and geometry necessary for 100 picosecond MPD switching speeds needed for robust survivability in high power electromagnetic fields.			
Title: Microsystems Research Consortium (MRC) ***Description:*** The Microsystems Research Consortium (MRC) program is a continuation and expansion of the FCRP industry-government partnership that will combine the expertise and resources from select defense, semiconductor, information systems, and automotive companies with DARPA. For every $3 from industry DARPA will provide $2. This funding will collectively support a well-focused community of the most talented academic research teams around the country to make the discoveries that will comprise microsystems of the future. For industry, the pre-competitive research produced by MRC represents the building blocks upon which they will grow their business to the next level. For government, it will accelerate the time frame from design to production of the new generation of defense systems, providing the high performance devices and applications needed by warfighters in the field. Research in the MRC program is divided into the broad categories of technology discovery and system discovery. Technology discovery efforts will be focused on providing a pipeline of innovative devices and basic discovery. In contrast, the system discovery efforts will focus on integration of existing technologies to provide new capabilities. These include, among many others, producing new opportunities for functionality beyond digital CMOS, and developing anticipatory technology, where systems interact actively with their environment and/or users, adapting their response to execute the most advantageous and effective actions. MRC is unique in that government participates as a partner on an equal ground as industry, with contracting function to pursue its goals directly rather than extracting indirect benefits from subsidizing technology. The program has a definite five year duration, with its leadership turning over periodically. ***FY 2013 Plans:*** - Initiate program with thrusts in technology discovery and systems discovery.	-	-	20.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
The technology discovery thrust includes: - Novel materials which enable new functions. - Integrated circuits and computing architectures based on novel technologies and devices including both digital and analog. - Concepts for large scale fabrication. The systems discovery thrust includes: - High performance analog for high speed wireless, TeraHertz electronics for imaging, sensing, novel power devices. - Vehicle and distributed sensor networks. - Computing systems architectures based on CMOS technology. - Tools and methods for design, verification and predictive modeling, including physical modeling.			
Title: Focus Center Research Program (FCRP)	20.400	20.400	-
Description: The Focus Center Research Program (FCRP) is a collaborative effort between the Defense Advanced Research Projects Agency (DARPA) and the semiconductor industry to concentrate research attention and resources to provide radical innovation in semiconductor technology. The program focuses on discovery research to provide solutions to barrier problems in the path of sustaining the historical productivity growth and performance enhancement of semiconductor integrated circuits. The overall goals of this collaborative effort between the DoD and industry is to sustain the unprecedented four decades of uninterrupted performance improvement in information processing power and fundamentally change the design cycle of electronic systems. ***FY 2011 Accomplishments:*** - Developed CMOS compatible optical modulators capable of moving the huge amounts of data required by future chip architectures. - Demonstrated silicon-compatible germanium-based optical modulators consuming only 14 femto-Joules per bit (1 fJ = 10-15 Joules) with 3.5 GHz modulation, with eventual operation close to a terahertz in frequency. - Demonstrated that Gallium Nitride technology combined with integrated magnetics for AC-DC on-chip power conversion can dramatically reduce overall computer power consumption by increasing the efficiency of power delivery. - Developed gate and insulator processes and devised means to integrate silicon and compound semiconductor devices together. - Developed wireless bio-medical implants for drug delivery inside the body using remote control via micro-propulsion. - Produced a prototype implementation for electrocardiography analysis using IBM's 45 nm CMOS process. ***FY 2012 Plans:*** - Continue to leverage industry funding for efforts, maintain formal and informal coupling and industry-based research for development and transition of technologies.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Transition innovative concepts developed with the university program to provide novel capabilities for DoD microelectronics systems.			
Title: Quantum Entanglement Science and Technology (QuEST) ***Description:*** The Quantum Entanglement Science and Technology (QuEST) program is exploring 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, 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. ***FY 2011 Accomplishments:*** - Continued fundamental research in the area of quantum information science. - Developed novel approach to interconversion between different qubit technologies. - Developed novel qubit architectures resistant to localized noise sources. - Demonstrated new qubit readout and manipulation techniques. - Developed new theoretical insights on the impact of environmental noise on inter-qubit entanglement. ***FY 2012 Plans:*** - Continue fundamental research in the area of quantum information. - Characterize and manipulate entangled quantum systems.	19.128	5.092	-
Title: N/MEMS Science and Focus Centers ***Description:*** The goal of the N/MEMS Science and Focus Centers program was to support the development of an enhanced fundamental understanding in a number of technical issues considered to be critical to the continuing advance of nanoelectromechanical systems (NEMS) and microelectromechanical systems (MEMS) technologies and their transition into military systems. The program supported basic research at seven university centers responding to recognized challenges in a comprehensive range of technical areas pertinent to future DoD micro/nano technology needs. Industrial cost sharing was an important element of the program, with industry matching DARPA resources on a 1:1 basis. ***FY 2011 Accomplishments:*** - Demonstrated working prototypes of independently actuated dual N/MEMS probes, multilayered phase change vias with 2x lower reset current and phase change reconfigurable RF, mixed-signal and digital circuits.	6.807	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated trapping and manipulation of nanoparticles with an optical nanotweezer consisting of a metallic nanostructure that focuses a laser beam to a sub-wavelength spot. - Demonstrated record fatigue performance (7.5% strain, > 5 x 1010 cycles, room temperature) in single crystal silicon resonators that are encapsulated using the large lateral-gap epi-seal process. - Developed advanced capabilities for measuring acceleration sensitivity measurement apparatus to the point of seeing gamma factors as low as 5.5x10-10 for a two-chip wire-bonded MEMS-based oscillator, which is considerably less sensitive to acceleration than the average quartz crystal oscillator and better than any other MEMS-based oscillator. - Demonstrated printed circuit board-based microfluidic chip capable of whole blood cell lysis (with 90% lysis efficiency in 3 minutes), and isotacho-phoretic extraction and purification of the nucleic acid targets from the lysate. - Demonstrated that adhesion of graphene to a substrate is 100,000X greater than that of a MEMS structure. - Demonstrated a large number of graphene mechanical transistors with single-layer graphene sheets successfully transferred onto a silicon substrate designed for the mechanical transistors. - Designed and demonstrated robust > 10 W RF MEMS metal-contact and capacitive switches.			
Title: Nanoscaled Architecture for Coherent Hyper-Optic Sources (NACHOS) ***Description:*** The objective of the Nanoscaled Architecture for Coherent Hyper-Optic Sources (NACHOS) program was to demonstrate sub-wavelength semiconductor lasers by leveraging recent developments in reduced dimensionality and advanced feedback concepts. The specific program goal was to demonstrate continuous wave injection lasers operating at room temperature with cavity dimensions smaller than the vacuum wavelength of light they generate, wavelength < 1.5 micrometers. Nanoscale lasers enabled close integration of photonic and electronic devices needed in emerging high-speed processing-intense computing and communication platforms. In addition to reduced size, these lasers are power-efficient and offer unprecedented modulation bandwidth. New capabilities, such as the ability to place large numbers of lasers on silicon chips, will be enabled by these devices. ***FY 2011 Accomplishments:*** - Demonstrated the world's smallest electrically-injected sub-wavelength lasers with power > 8 microwatts. - Developed novel, light-emitting, silicon nano-wires that are highly tunable and easily integrated into a CMOS platform. - Developed a near thresholdless laser capable of initiating lasing at extremely low powers of 0.1 nanowatts (10,000x less than a conventional laser).	4.189	-	-
Title: Tip-Based Nanofabrication (TBN) ***Description:*** The Tip-Based Nanofabrication (TBN) program developed the capability to controllably manufacture, for selected defense applications, nano-scale structures such as nanowires, nanotubes, and quantum dots with nanometer-scale control over the size, orientation, and position of each nanostructure, using Atomic Force Microscope (AFM) cantilevers and tips. The selected	11.618	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
defense applications included optical and biological sensors, diode lasers, light emitting diodes, infrared sensors, high density interconnects, and quantum computing. In addition to tip-based approaches, other methods for controlled nano-manufacturing were considered, including optical and bio-inspired approaches. ***FY 2011 Accomplishments:*** - Demonstrated operation of multi-tip arrays for use in manufacturing complex components. - Demonstrated precision and control of the process and functionality for specific device designs. - Demonstrated a low cost and scalable tip-based array of nano-patterning elements (>20,000 elements) that allows for high throughput nano-fabrication and high resolution (< 50 nanometers) over large areas. - Demonstrated the fabrication of semiconducting nanowires, graphene ribbons, quantum dots, Kane q-bits, carbon nanotubes and other structures using tips-based nano-manufacturing (TBN) for specific device applications.			
Title: Centers for Integrated Photonics Engineering Research (CIPhER) ***Description:*** The Centers for Integrated Photonics Engineering Research (CIPhER) program explored and enhanced fundamental understanding in the development and application of integrated photonics, in which an entire photonic system is fabricated on a single chip. Much like integrated electronics, integrated photonics has the potential to enable photonics systems to reach revolutionary new levels of performance and functionality, but with a wide range of applications, including such areas as imaging, energy conversion, signal processing, and computing. The CIPhER program used a government/industrial cost-share funding model to foster the next generation of fundamental university-based photonics research. The CIPhER program was directed toward achieving this objective through the establishment of collaborative theme-based focus centers. Focus centers were comprised of university-led teams, with industrial partners, engaged in long-term basic research of photonic materials, devices, and microsystems. ***FY 2011 Accomplishments:*** - Demonstrated record low loss coupling light from free space to a photonic integrated circuit at only 5% power loss into a silicon-on-insulator waveguide. - Developed and demonstrated a complete free-space communication link at 2000 nanometers capable of leveraging telecommunications hardware designed for 1550 nm by taking advantage of non-linear wavelength conversion in silicon. - Demonstrated a 5 fold enhancement in Surface Enhanced Raman Spectroscopy (SERS) by placing gold nano-cages on photonic micro-rings and mapped the response of the influenza virus to various glycans. Together these two advancements allowed for both highly specific and highly sensitive biological agent identification.	7.072	-	-
Accomplishments/Planned Programs Subtotals	74.477	42.145	53.163

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C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
MS-01: *MATERIALS SCIENCES*	90.916	99.506	76.340	-	76.340	76.450	76.824	79.824	90.263	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project provides the fundamental research that underpins the development of advanced nanoscale and bio-molecular materials, devices, and electronics for DoD applications that greatly enhance soldier awareness, capability, security, and survivability, such as materials with increased strength-to-weight ratio and ultra-low size, devices with ultra-low energy dissipation and power, and electronics with persistent intelligence and improved surveillance capabilities.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Nanoscale/Bio-inspired and MetaMaterials	7.983	10.000	14.140

Description: The research in this thrust area exploits advances in nanoscale and bio-inspired materials, including computationally based materials science, in order to develop unique microstructures and material properties. This area also includes efforts to develop the underlying physics for the behavior of materials whose properties have been engineered at the nanoscale level (metamaterials) and materials exhibiting a permanent electric charge (charged matter).

FY 2011 Accomplishments:
- Identified, through fractographic analysis, the strength-limiting flaws in nano-composite optical ceramics related to processing conditions.
- Demonstrated controlled fabrication of biophotonic structures.
- Applied scalable fabrication methods for bioinspired structures to demonstrate versatile spectroscopy for sensing and monitoring.
- Initiated computation to demonstrate that selected properties may be independently manipulated as a function of identified architectural parameters, to a regime currently unachievable.
- Initiated development of scalable fabrication methodologies of microtruss structures with control of strut element dimensions down to the micron length scale.
- Initiated development of capability to achieve multidimensional control of microstructural architecture and incorporate features with curvilinear geometries.

FY 2012 Plans:
- Apply fabrication techniques to produce materials with architectural features necessary to exhibit predicted properties, such as high strength at low density.
- Experimentally characterize effects of varying architectural features on selected material properties.
- Perform sensitivity analyses to develop and validate optimization algorithms for material properties.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiate development of multidimensional architecture-to-property design space fabrication of materials with architectural features necessary to exhibit predicted properties. ***FY 2013 Plans:*** - Optimize fabrication methods of materials with architectural features necessary to exhibit predicted properties. - Initiate experimental optimization of architectural features to demonstrate improvement of selected material properties, such as strength, density, and stiffness, based on sensitivity analyses and experimental characterization. - Continue development of multi-dimensional architecture-to-property design space fabrication of materials with architectural features necessary to exhibit predicted properties. - Initiate studies to determine extent to which properties normally coupled, can be decoupled using architecture-to-properties design methodology. - Initiate scalability studies to determine degree to which fabrication methods are amenable to scaling and degree to which architectural control can be maintained.			
Title: Fundamentals of Nanoscale and Emergent Effects and Engineered Devices ***Description:*** The Fundamentals of Nanoscale and Emergent Effects and Engineered Devices program seeks to understand and exploit physical phenomena for developing more efficient and powerful devices. This includes developing devices and structures to enable controllable photonic devices at multiple wavelengths, engineering palladium microstructures with large deuterium loadings to study absorption thermodynamics and effects, enabling real-time detection as well as analysis of signals and molecules and origin of emergent behavior in correlated electron devices, and developing stabilization and scale-up methods to fabricate high pressure crystal structures at low pressures. Arrays of engineered nanoscale devices will result in an order of magnitude (10 to 100 times) reduction in the time required for analysis and identification of known and unknown (engineered) molecules. This program will develop novel nanomaterials for exquisitely precise purification of materials, enabling such diverse applications as oxygen generation and desalination, ultra-high sensitivity magnetic sensors, and correlated electron effects such as superconductivity. This program will compare the phenomenology of various biological, physical and social systems and abstract the common features that are responsible for their properties of self-organization, emergent behavior, and physical intelligence. ***FY 2011 Accomplishments:*** - Demonstrated a 50 percent yield for the fabrication of the magnetic sensors based on multiferroic composites, in a lot size of 10 units which have outputs (volt/tesla values) within 10 percent of the specification. - Demonstrated a 50 percent yield for the fabrication of the magnetic sensors based on atomic vapor cells, in a lot size of 10 units which have outputs (volt/tesla values) within 10 percent of the specification. - Demonstrated a multiferroic magnetic sensor with an optical circuit read-out.	16.745	11.650	5.500

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Determined the requirements for a unified theory for a non-biological system to demonstrate biological-like physical intelligence and showed how it is consistent with thermodynamic and other physical principles. - Using a combination of simulation and real system hardware, conducted limited demonstrations of self-organizing electronic and chemical systems imbedded in environments of limited complexity and responding to environmental pressures. - Formalized preliminary model systems and evaluated the initial physical intelligence theory's ability to describe the candidate electronic, physical, and chemical systems. - Refined analytical tools to measure intelligence and demonstrate them on complex, real world systems and their associated data, such as human subject data and social networks. - Developed more complex demonstrations with multiple stimuli and feedback considerations and extended the theoretical and analytical tools to more complex systems. - Continued quantification of material parameters that control degree of increase in excess heat generation and life expectancy of power cells in collaboration with the Italian Department of Energy. Established ability to extend active heat generation time from minutes to 2.5 days for pressure-activated power cells. ***FY 2012 Plans:*** - Verify the initial unified physical intelligence theory and justify its underlying assumptions in the context of model systems that supports the emergence and evolution of novel structure. - Expand the theoretical effort to include casual entropy and address correlated effects such as self-organized criticality, renormalization, scaling, and punctuated equilibrium. - Demonstrate the spontaneous, abiotic evolution and complex spatial and temporal organization in electro-chemical-physical systems in response to structure and resources from the environment. - Quantify the emergent hierarchical structures that evolve from the demonstrated electro-chemical-physical systems. - Demonstrate the ability to design an evolving electro-chemical-physical system and direct its evolution toward specified objectives in the form of a challenge problem or application. - Initiate development of computational tools to formulate processing pathways to stabilize and scale up high pressure crystal phases. - Establish scalability and scaling parameters in excess heat generation processes in collaboration with the Italian Department of Energy. ***FY 2013 Plans:*** - Initiate efforts to identify and characterize metastable solid phases of gaseous materials that have superior mechanical/ functional properties. - Initiate development of synthesis techniques for producing extended solids at temperature and pressures amenable to scale up.			
Title: Atomic Scale Materials and Devices	16.030	9.563	2.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013

Description: This thrust examines the fundamental physics of materials at the atomic scale in order to develop new devices and capabilities. A 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. A new all optical switch capability will also be investigated. It includes a new, non-invasive method to directly hyperpolarize biological tissues, leading to novel quantitative neurodiagnostics. New materials and prototype devices will be developed to demonstrate a new class of optoelectronics that operate with ultra-low energy dissipation (~100 atom-Joules (aJ)/operation).

FY 2011 Accomplishments:

- Demonstrated production of antiferromagnetically ordered states in 2-D optical lattices.
- Studied and characterized supersolid behavior in multi-spin Bose condensates.
- Experimentally produced phase diagrams of strongly interacting fermion gases in less than twelve hours.
- Realized synthetically charged atoms and artificial magnetic fields in preparation for studies of fractional quantum Hall effect physics.
- Demonstrated all-optical switch based on optically-induced absorption.
- Demonstrated total energy dissipation for an optical switch of 2.3 attojoules per operation, and best case signal loss of less than 0.1 decibel (dB), excluding waveguide losses before and after device, at a temperature of 27 Kelvin.
- Demonstrated all-optical switching using two photon absorption with organic molecules (7C TCF cyanine, 2PA (two photon) cross-section of 750 GM (Goeppert-Mayers) when measured in processed film on silica), inverse Raman scattering with organic molecules and Zeno chi (2) effect crystals.
- Demonstrated and independently verified visible light with Orbital Angular Momentum (OAM) induces 1.5 percent nuclear polarization equivalent -- to a 2000 tesla magnet.
- Endowed a 12.8 kilo electron volt X-ray beam with OAM=40 -- the highest OAM value imparted for that X-ray energy.
- Demonstrated X-rays with OAM induces 0.15 percent nuclear polarization -- 200x larger than current state of the art.

FY 2012 Plans:

- Load polar molecules into optical lattices to study long-range character and ordering inside the optical lattice.
- Produce phase diagrams of frustrated quantum antiferromagnets.
- Produce phase diagrams of 2-D Fermi-Hubbard model at near half-filling; determine presence or absence of superfluid phase.
- Demonstrate all-optical switch (or equivalent device) based on optically-induced absorption for a 25 nanometer range in input wavelength.
- Demonstrate total energy dissipation for an optical switch (or equivalent device) of less than 100 attojoules per operation, and signal loss of less than 0.05 dB, excluding waveguide losses before and after device, at room temperature.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiate development of high efficiency X-ray optics appropriate for broadband, bench top X-ray sources. ***FY 2013 Plans:*** - Demonstrate switch fabric of at least 2 concatenated all-optical switches, each with less than 100 attojoules total energy dissipation (not counting waveguide losses).			
Title: Basic Photon Science	10.452	21.500	13.000
Description: Initiated under the Fundamentals of Nanoscale Devices effort, the Basic Photon Science thrust is examining the fundamental science of photons, from their inherent information carrying capability (both quantum mechanically and classically), to novel modulation techniques using not only amplitude and phase, but also orbital angular momentum. The new capabilities driven by this science will impact DoD through potentially novel approaches to communications and imaging applications, in addition to better understanding the physical limits of such advancement. For example, fully exploiting the computational imaging paradigm and associated emerging technologies to yield ultra-low size, weight, and power persistent/multi-functional intelligence, surveillance, and reconnaissance systems that greatly enhance soldier awareness, capability, security, and survivability. ***FY 2011 Accomplishments:*** - Investigated the theoretical and practical limits to the information content of a single photon via rigorous application of information theory. - Investigated the utility of information theoretic approach for design and improved receivers for high data rate communications. - Investigated the utility of information theoretic approach for improved low-light level imaging. - Developed the basic science required for the exploitation of orbital angular momentum in both the classical and quantum realms. - Began to study the fundamental limits of computational imaging by quantifying the space of cost and performance. - Began to develop the mathematical tools required to facilitate the joint optimization of physical and computational degrees of freedom. ***FY 2012 Plans:*** - Investigate the practical limits to the information content of a single photon via inclusion of various real-world imperfections. - Demonstrate the utility of information theoretic approach via highly photon-efficient communications. - Demonstrate the utility of information theoretic approach via improved low-light level imaging. - Demonstrate the benefit of orbital angular momentum for communications applications. - Evaluate the information capacity of candidate ghost imaging systems. - Characterize surfaces of constant performance in the space of camera cost factors including optics, focal planes, and computation. - Study the fundamental limits of wafer scale optical fabrication and the capabilities of in situ 3-D optical metrology.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Investigate novel non-imaging measurements enabled by 3-D design and fabrication. - Develop a collection of candidate computational camera designs that yield high performance and low size, weight and power. ***FY 2013 Plans:*** - Demonstrate classical optical communications with an information rate of 10 bits per photon. - Demonstrate quantum mechanically secure communications at a secure key information rate of 10 bits per photon. - Demonstrate novel technologies for encoding and decoding orbital angular momentum. - Demonstrate low-light level imaging at an information rate of 5 bits per photon.			
Title: Enabling Quantum Technologies ***Description:*** This thrust emphasizes a quantum focus on technology capabilities including significantly improved single photon sources, detectors, and associated devices useful for quantum metrology, communications, and imaging applications. In addition, this thrust will examine other novel classes of materials and phenomena such as plasmons or Bose-Einstein Condensates (BEC) that have the potential to provide novel capabilities in the quantum regime, such as GPS-independent navigation via atom interferometry and communications, and ultrafast laser technologies. ***FY 2011 Accomplishments:*** - Designed a physics package for an optical clock including lasers, optomechanics, associated electronics, and environmental isolation and control subsystems. - Determined the mechanical stability of doped-crystal Fabry-Perot optical cavities for use in time and frequency transfer between optical clocks. - Investigated techniques to improve the coherence properties of nitrogen-vacancy diamond nanocrystals for use in high resolution magnetometry. - Achieved photonic cooling of a nanomechanical oscillator to its quantum ground state. ***FY 2012 Plans:*** - Demonstrate an optomechanical accelerometer with sensitivity of 10 micro-g/hertz^1/2 sensitivity and 1 kilohertz bandwidth. - Demonstrate diamond magnetometer with < 5 microtesla/hertz^1/2 and < 10 nanometer resolution. - Demonstrate a compact cold alkaline beam source for an optical clock. - Investigate the feasibility of high average power, ultrafast laser architectures suitable for high throughput industrial micromachining. ***FY 2013 Plans:*** - Demonstrate an optomechanical accelerometer with sensitivity of 1 micro-g/Hz^1/2 sensitivity and 1 kHz bandwidth. - Demonstrate an integrated optomechanical device for coupling optical and microwave photons. - Use diamond-atomic force microscopy magnetometer to sense one electron spin on a surface with spatial resolution <5 nm.	8.385	9.233	15.700

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrate a compact optical clock. - Demonstrate on-chip, octave-spanning frequency comb with 200 GHz line spacing. - Explore schemes extending frequency combs from the extreme UV into the medium wavelength infrared (MWIR) and long wavelength infrared (LWIR) spectral regimes for applications of interest to the DoD. - Examine the utility of robust, compact attosecond probes for real-time control of atomic excitations, valence electron dynamics, and transport phenomena in ultra-dense matter.			
Title: Fundamentals of Physical Phenomena	9.712	13.560	11.000
Description: This thrust will obtain insights into physical aspects of natural phenomena such as magnetospheric sub-storms, fire, lightning, and geo-physical phenomena. New fundamental understandings of these phenomena will enable the ability to predict and exploit these physical processes, especially with regard to communications. A major emphasis of this thrust is to provide predictive models for the interactions between plasmas and electromagnetic waves across a range of energy and length scales, and into new regimes. Specific projects that fall under this heading are foundational studies on the initiation, propagation, and attachment of lightning, and their associated emissions; the critical factors affecting magnetospheric sub-storms; the generation and amplification of extremely low frequency (ELF)/ultra low frequency (ULF)/very low frequency (VLF) radiation in the ionosphere utilizing the High Frequency Active Aural Research Program (HAARP) transmitter; and understanding and quantifying the interaction of electromagnetic and acoustic waves with the plasma in flames.			
FY 2011 Accomplishments: - Investigated unexpected, GPS-derived total electron enhancements (25 percent larger than previously observed) and overshoots and the mechanisms behind these phenomena, which may provide significant insight into artificial ionization caused by descending plasma plumes. - Conducted a comprehensive series of ELF/ULF/VLF generation experiments and accomplished first ever generation of ELF waves (10-50 Hz) without the presence of a Polar Auroral electrojet using the ionospheric current drive (ICD). - Characterized ionospheric current drive (ICD), artificially stimulated emissions in the ionosphere, and ionospheric turbulence and associated scintillations. - Developed and implemented a continuously-operational, comprehensive array of instruments that measure emissions generated by tropospheric lightning, the associated electric and magnetic fields, and the appropriate time derivatives of these fields which indicate how rapidly they change. - Discovered potential correlation between compact intracloud discharges (CIDs) and gigantic blue jets (leaders that extend up to 35 km in altitude). - Deployed balloons into thunderstorms to make in-situ electric field, X-ray and gamma-ray measurements.			
FY 2012 Plans:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Characterize conditions surrounding artificial duct creation and conduct experiments to determine mechanisms by which VLF waves can be injected into these ducts. - Conduct a series of experiments to quantify D-region absorption, F-region irregularities, spatial distribution of ELF/VLF source currents, and Electrojet electric fields. - Conduct a series of experiments to optimize the efficiency of ULF generation and potentially gain active control of their lateral propagation paths and injection into the magnetosphere. - Conduct comprehensive research campaigns using both triggered and natural lightning during the fall/winter storm seasons to measure all atmospheric, electromagnetic and ionospheric phenomena associated with positively-charged-winter-time lightning. - Conduct comprehensive fall/winter research campaigns to study the initiation of transient luminous events, early VLF events, and lightning-induced electron precipitation events by providing the known event timing, location, and properties inherent to rocket-triggered lightning. ***FY 2013 Plans:*** - Conduct numerical studies of ion dynamics caused by ULF, and of VLF wave propagation through the ionosphere inside density ducts created by artificial heating. - Experimentally attempt 3-D observations of HF-induced plasma structures and potentially determine relative HF power absorption for different altitudes, frequencies and geophysical conditions. - Experimentally quantify the impact of triggered lightning on properties of natural lightning (including the emission of gamma rays, X-rays, UV, VNIR/SWIR, RF,VLF/ULF) and on the properties of ionospheric phenomena (elves, sprites, whistlers, etc.). - Experimentally quantify the impact of tropospheric lightning (both triggered and natural) and its ionospheric components on the conductivity of the ionosphere and the resultant scattering of sub-ionospherically-propagating VLF signals. - Experimentally quantify the impact of CIDs on lightning propagation as well as their potential contribution to the production of very large blue jets.			
Title: MesoDynamical Architectures (Meso)*	20.809	24.000	15.000
Description: *Includes the former Dynamics-Enabled Frequency Sources (DEFYS) program. The Mesodynamic Architectures (Meso) program is demonstrating transformative technologies based on recently discovered physics and materials to redefine building blocks of modern microsystems. The program is divided into four technical thrusts: coherent collective dynamics, information transduction, nonlinearity and noise, and coherent feedback control. Each of these efforts is focused on demonstrating specific technologies, including transistors based on a novel state of matter (Topological Insulators) and communication links embedded within adversary's jamming signals based on high-purity oscillators. ***FY 2011 Accomplishments:*** Nonlinearity and Noise Thrust:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Achieved record performance levels for compact-high-purity frequency sources. Performance confirmed by third party testing. Verified measurements significantly exceeded phase metrics: 698 MHz fundamental frequency (metric 500 MHz) with 110 decibels (dBc)/Hz phase noise (metric -90 dBc/Hz) at 1 kHz offset. Associated Allan deviation confirmed to be 0.6 parts per billion. - Three separate nonlinear mechanisms identified that improve oscillator performance. - Developed microscale oscillators of navigation grade. Included initial prototype in defense GPS equipment to demonstrate acquisition and tracking of GPS. - Developed technology to hide signals with low probability of detection within an adversary's jammer. - Achieved vibration isolation 3x10-12 /g allowing operation in vibrating systems (e.g., helicopters). Coherent Collective Dynamics (Topological Insulators) Thrust: - Developed physics of topological insulators guiding the production of interconnects to transmit electricity/information with orders of magnitude lower power and lower losses than the best performing known technology. - Reproduced first ever magnet whose direction of magnetization can be controlled via applied voltage, which together with topological surface states will result in an ultra low power transistor useful well beyond the impending end of Moore's Law. - Produced the first ever topological insulator based field effect transistor. Information Transduction Thrust: - Developed novel method to measure conductance produced via transduction of molecular motion, and used it to reproducibly identify individual molecule species in a large liquid background. This will allow production of the first ever handheld, accurate electronic biomolecular sensor for use in-theater. - Produced and successfully tested the first prototypes of novel information transducers with improved performance and reduced noise. Coherent Feedback Control Thrust: - Completed initial specification of a computer language which engineers can use to properly design quantum stabilized nanophotonic circuits. - Designed basic logic components requiring minimal physical resources for ultra-low power photonic digital signal processing.			
FY 2012 Plans: Nonlinearity and Noise Thrust: - Reduce phase noise 30 decibels over existing electromechanical alternatives by using noise-driven dynamics. Meet physical size metric of 1cm3, acceleration sensitivity requirement, and temperature stability of < 30 ppm, for operating frequency of 800 MHz.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Coherent Collective Dynamics (Topological Insulators) Thrust: - Optimize the properties of topological insulating materials. - Improve surface conduction in materials while reducing their bulk conduction. - Develop and test first prototypes of topological insulators, transistor and interconnects. Information Transduction Thrust: - Demonstrate first portable, electronic biomolecular sensor with low noise, high accuracy, efficiency, detection capability, and throughput. - Develop and characterize high quality materials for construction of new devices and build first generation prototype structures with optimal performance. Coherent Feedback Control Thrust: - Develop computational simulation engine for nanophotonic circuits stabilized via coherent quantum feedback. - Design nanophotonic circuits with multiple components, atto-Joules switching energy and nanoseconds switching time.			
FY 2013 Plans: Nonlinearity and Noise Thrust: - Demonstrate new effects and engineering breakthroughs to provide compact, ultra-high-purity sources. - Decrease acceleration sensitivity and improve temperature stability. - Demonstrate new radar capabilities in a high vibration environment (e.g., detecting slow moving objects in a helicopter). Coherent Collective Dynamics (Topological Insulators) Thrust: - Optimize and integrate materials at large scale to achieve a magnetically gated, ultra-low power, ultra-high switching speed topological insulator transistor; and ultra-low dissipation, programmable interconnects for electronic components. Information Transduction Thrust: - Produce next generation prototype structures for information transduction with extended lifetime and bandwidth, and reduced noise and operating power. - Reduce noise and current required for operation of the electronic biomolecular sensor increasing its detection capacity and resolution. Coherent Feedback Control Thrust: - Increase the number of devices per optimization handled by the computational simulation engine.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Fabricate nanophotonic circuits with multiple components, femto-Joules switching energy, 10 ns switching time, and 2x error suppression via coherent feedback control.			
Title: Surface Enhanced Raman Scattering (SERS) - Science and Technology Fundamentals	0.800	-	-
Description: The Surface Enhanced Raman Scattering (SERS) - Science and Technology program focused on the fundamental technical challenges facing potential sensor performance with respect to their sensitivity, selectivity, enhancement factors and development. SERS nanoparticles have considerable potential for both chemical and biologic sensing applications due to potential: 1) large spectral enhancement factors, 2) spectral fingerprints that can be expected to yield low false alarm rates, and 3) capability to detect targeted molecules at useful stand-off ranges. This program sought to identify and overcome the key scientific and technical challenges necessary for replacing existing sensors of chemical and biological warfare (CBW) agents with SERS-based sensing approaches. ***FY 2011 Accomplishments:*** - SERS nanofinger substrates exceeded enhancements of 10e11. SERS nanoparticles with internal reflectors attained enhancements of >10e10. Both were incorporated into large (>6") printed sensing substrates. - Demonstrated control of both resonance frequencies and SERS enhancement spectra by tuning the geometrical parameters of double resonance substrates. SERS enhancement of over 10e9 has been successfully observed using an eye-safe laser wavelength of 1064 nanometers. - Free surface microfluidic structures were successfully coupled with SERS to detect vapors of various substances, including vapors of the explosive pentaerythritol tetranitrate (PETN) down to 80 parts per quadrillion. - Theoretical modeling was performed which indicates that metamaterial-like nanostructures can improve light-to-matter coupling of SERS nano-antennas. - Research continued into military relevant SERS applications. Selective and reversible binding of Sarin on a SERS substrate was developed. Quantitative, transdermal, in vivo analysis of glucose was also achieved.			
Accomplishments/Planned Programs Subtotals	90.916	99.506	76.340

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
TRS-01: *TRANSFORMATIVE SCIENCES*	21.809	37.954	47.269	-	47.269	63.441	59.561	64.561	65.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Transformative Sciences project supports research and analysis that leverages converging technological forces and transformational trends in computing and the computing-reliant subareas of the social sciences, life sciences, manufacturing, and commerce. The project integrates these diverse disciplines to improve military adaptation to sudden changes in requirements, threats, and emerging/converging trends, especially trends that have the potential to disrupt military operations. The primary focus of this project is custom manufacturing; large-scale, human-centered networks; and cyber-human-physical systems. Promising research will advance to both technology development and system-level projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Social Media in Strategic Communication (SMISC)*	3.571	8.300	16.720

Description: *Formerly Crowd-Sourced Analytics

The Social Media in Strategic Communication (SMISC) program will develop techniques to detect, classify, measure and track the formation, development and spread of ideas and concepts (memes) in social media. This will provide warfighters and intelligence analysts with indications and warnings of adversary efforts to propagate purposefully deceptive messaging and misinformation. Social media creates vulnerabilities that can be exploited to harm U.S. interests and threaten national security and have become a key operating environment for a broad range of extremists. SMISC will develop technology and a new supporting foundational science of social networks that will enable warfighters to defend against malevolent use of social media and to counter extremist influence operations.

FY 2011 Accomplishments:
- Established analytical framework and defined initial approaches for quantitative assessment.

FY 2012 Plans:
- Develop formal representations for social context.
- Apply and adapt new natural language processing techniques to social media where highly contracted forms of communication are the rule.
- Develop big graph models and advanced analytics for social dynamics in social media.
- Develop algorithms for detecting, classifying, measuring and tracking the formation, development and spread of ideas and concepts (memes) in social media.

FY 2013 Plans:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Tailor specialized algorithms to recognize purposeful or deceptive messaging and misinformation, persuasion campaigns, and influence operations across social media. - Demonstrate methods for countering adversary influence operations using techniques of semi-automated narrative creation based on predictive social dynamic models.			
Title: Open Manufacturing* ***Description:*** *Formerly part of Transformative Sciences The Open Manufacturing program will reduce barriers to manufacturing innovation, speed, and affordability of materials, components, and structures. This will be achieved by investing in technologies to enable affordable, rapid, adaptable, and energy-efficient manufacturing and to promote comprehensive design, simulation and performance-prediction tools, and exposure to best practices. ***FY 2011 Accomplishments:*** - Established manufacturing demonstration centers. - Identified mechanisms for protecting intellectual property and disseminating best practices. ***FY 2012 Plans:*** - Identify experiments and targeted tests that rapidly optimize part qualification processes. - Develop simulation tools that allow rapid predictions of guaranteed performance in actual manufactured products. - Develop new manufacturing/fabrication capabilities that allow for low-volume production runs with the same economies as high-volume ones. - Initiate process and process models that enable rapid setup and processing thereby reducing entry costs and timelines. - Establish manufacturing demonstration centers of expertises that increase access and expand the base of manufacturing. ***FY 2013 Plans:*** - Establish tools that capture the impact of manufacturing practice and non-linear interactions between components and subsystems and that incorporate parametric and declarative attributes. - Develop and demonstrate rapid, robust manufacture processes with improved key materials properties and reduction in cost and time over baseline. - Establish models that incorporate uncertainty, and develop ways to chain models together, with uncertainty embedded in each stage, to predict and guarantee that the range of performance lies within required boundaries. - Develop new testing methodologies and protocols that support rapid qualification of products. - Demonstrate impartial manufacturing centers of expertise by providing infrastructure to non-traditional suppliers for demonstration, testing, and qualification of new manufacturing technologies.	3.500	12.000	13.500

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Perform virtual manufacturing system exercises that pass design, manufacture, and verification of a specific part through the entire chain.			
Title: Living Foundries*	2.500	15.000	10.549

Description: *Formerly part of Synthetic Biology

The goal of Living Foundries is to create a revolutionary, biologically-based manufacturing platform to provide new materials, capabilities and manufacturing paradigms for the DoD and the Nation. The program seeks to develop the new tools, technologies and methodologies to transform biology into an engineering practice, speeding the biological design-build-test cycle and expanding the complexity of systems that can be engineered. The goal is to enable the rapid development of previously unattainable technologies and products, leveraging biology to solve challenges associated with production of new materials, novel capabilities, fuels and medicines and providing novel solutions and enhancements to military needs and capabilities. For example, one motivating, widespread and currently intractable problem is that of corrosion/materials degradation - a challenge that costs the DoD nearly $23 billion per year and has no near term solution in sight. Living Foundries offers the potential to program and engineer biology, and enable the capability to design and engineer systems that rapidly and dynamically prevent, seek out, identify and repair corrosion/materials degradation. Ultimately, Living Foundries aims to provide game-changing manufacturing paradigms for the DoD, enabling distributed, adaptable, on-demand production of critical and high-value materials, devices and capabilities in the field or on base. Such a capability will decrease the DoD's dependence on tenuous material and energy supply chains that could be cut due to political change, targeted attack or environmental accident.

Living Foundries aims to do for biology what very-large-scale integration (VLSI) did for the semiconductor device industry - i.e. enable the design and engineering of increasingly complex systems to address and enhance military needs and capabilities. Living Foundries will develop and apply an engineering framework to biology that decouples biological design from fabrication, yields design rules and tools, and manages biological complexity through simplification, abstraction and standardization. The result will be to enable the design and implementation of complex, higher-order genetic networks with programmable functionality and DoD applicability. Research thrusts include developing the fundamental tools, capabilities and methodologies to accelerate the biological design-build-test cycle, thereby reducing extensive cost and time it takes to engineer new systems and expanding the complexity and accuracy of designs that can be built. Specific tools and capabilities include: interoperable tools for design, modeling, and automated fabrication; modular regulatory elements devices and circuits for hierarchical and scalable engineering; standardized test platforms and chassis; and novel approaches to process measurement, validation and debugging. Applied research for this program continues in FY 2013 in PE 0602715E, project MBT-02.

FY 2011 Accomplishments:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Began development of high-level design and compilation techniques for programming, constructing and modeling synthetic genetic regulatory networks. - Initiated characterization and testing of genetic parts and regulators and their assembly into simple circuits to begin to demonstrate ability to design and build workable and robust designs. - Began the design and development of automation software and components for automated assembly of engineered systems. ***FY 2012 Plans:*** - Continue development of high-level design, automation and construction tools to increase the efficiency, sophistication, and scale of possible designs. - Continue the design and development of modular regulatory elements, parts and devices necessary to build hierarchical, complex genetic networks. - Initiate development of orthogonal parts, devices circuits and systems in order to mitigate system cross-talk. - Initiate investigation, design, and development of standard test platforms and chassis that predictably interact with new genetic circuitry. - Initiate design and development of new quantitative, high-throughput measurement and debugging tools to test and validate the operation of synthetic regulatory networks. ***FY 2013 Plans:*** - Continue development of standardized test platforms and chassis and begin modeling studies to predict platform behavior. - Continue development of orthogonal genetic networks to demonstrate ability to limit cross-talk with native systems. - Begin designing, constructing, modeling, and testing of large scale, hierarchical genetic networks to demonstrate ability to do forward engineering of systems and functions. - Continue development and testing of characterization and debugging tools for synthetic regulatory networks.			
Title: Cognitive Cloud ***Description:*** The Cognitive Cloud program combines cloud computing (internet-based utility computing) and crowd-sourcing (large-scale, human-centered networks of web-enabled individuals working towards a unified goal) to create solutions for highly complex military problems. Examples of such problems include intelligence, surveillance and reconnaissance of denied areas; modeling foreign societies, governments, and militaries; debugging large, complex software systems; and real-time understanding of activity patterns indicative of imminent cyber-attack. A social compiler which views people, computer, and network ensembles as elements of a single architecture and enables crowd sourced developers to write social programs in a high-level language would automatically decompose the task and organize, incentivize, and outsource appropriate aspects to peer production. The resulting social computing systems could be applied both within the military and across larger communities to achieve capabilities ranging from highly responsive development of tactics, techniques, and procedures to open-source intelligence and strategic communications.	2.300	2.654	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2011 Accomplishments: - Conceptualized an approach to automating crowd-sourcing through social compilation. - Created an approach to software engineering and system development that provides end-to-end semantic modeling of a component-based system. - Developed a computing architecture that accepts sensor data as input and outputs human-level concepts such as object class, object features, and activity patterns. - Developed a model-driven development framework for semantically rich control, planning and cognitive systems. ***FY 2012 Plans:*** - Demonstrate how statistical and quasi-experimental analyses of existing data sets can be used to derive answers to key tactical military questions. - Demonstrate approaches for reactive, adaptable, and agile wide-area networks and computing systems.			
Title: Bits to Behavior via Brains (B3) ***Description:*** The Bits to Behavior via Brains (B3) program extends recent work indicating avatar activity in virtual worlds can result in measurable differences in real-world behavior on the part of users. One example of this observation is an increase in physical exercise undertaken by humans when their virtual avatar begins an exercise regimen. Understanding the neural mechanisms that govern the transfer of virtual behavior into actual behavior will enable optimization of virtual resources to train and educate soldiers, and could lead to therapeutic and preventative capabilities. B3 will examine how virtual world interactions influence neural mechanisms of learning (both one-shot and traditional) and executive function (especially judgment). This will be used to enable designers of virtual worlds to determine the methods and themes that will result in the most effective avatar-based virtual environment for military training and decision making. ***FY 2013 Plans:*** - Confirm and extend foundational work on characteristics of avatars to understand real-world decision making processes. - Explore neural mechanisms responsible for decision making processes; confirm avatar-mediated modulation of neurobiological operations as a transferrable tool for optimal learning and decision making. - Begin testing for individual and population-level behavioral differences in response to virtual training environments.	-	-	6.500
Title: Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) ***Description:*** *Formerly part of Synthetic Biology The Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) program develops technologies to rapidly respond to a disease or threat, and improve individual readiness and total force health protection. This program utilizes synthetic genetic	8.578	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
circuits to control cellular machinery and includes research to optimize orthogonality and modularity of genetic control elements, identify methods to increase sensitivity and specificity, and demonstrate methods to control cellular machinery in response to changes in physiological status. ADEPT enables the production of RNA-based vaccines, potentially eliminating the time and labor required for traditional manufacture of a vaccine while improving efficacy and safety. ADEPT also develops methodologies for measuring health-specific biomarkers from a collected biospecimen to enable diagnostics at the point-of-need (similar to home-use settings) or in resource-limited clinical facilities (i.e., point-of-care), in-garrison or deployed. The ADEPT program continues in FY 2012 in PE 0601117E, Project MED-01. Applied research for this program is funded in PE 0602115E, Project BT-01. ***FY 2011 Accomplishments:*** - Initiated the creation of synthetic biological elements that operate in mammalian cells. - Investigated the behavior of combining biological elements and determined their functional outcomes. - Initiated development of RNA-based vaccines. - Initiated the development of new concepts and techniques for compact, deployable diagnostics. - Investigated methods for biospecimen stabilization at room temperature.			
Title: Production of Knowledge Bases to Bridge Cultural Divides ***Description:*** The Production of Knowledge Bases to Bridge Cultural Divides program developed tools, techniques, and frameworks for the automated interpretation and quantitative analysis of social networks using emerging methods for edge finding and cluster analysis. These systems have important applications in tactical contexts to aid analysts and operators in connecting the dots amid complex, conflicting, and incomplete data sets. They also establish a foundation for cultural intelligence -- understanding the stability, governance, and economic indicators of a region. These technologies have transitioned into the Nexus 7 program in PE 0602702E, Project TT-13. ***FY 2011 Accomplishments:*** - Developed mathematical and algorithmic modeling and analysis tools. - Established baseline performance and demonstration of enhanced analysis using the tools. - Demonstrated automated and semi-automated processes for exploitation of data collected via experimental analyst assistant. - Deployed initial analytic results to commanders in Afghanistan.	1.360	-	-
Accomplishments/Planned Programs Subtotals	21.809	37.954	47.269

C. Other Program Funding Summary ($ in Millions)

N/A

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D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.