Department of Defense
Fiscal Year (FY) 2011 President's Budget

February 2010

Defense Advanced Research Projects Agency

Justification Book Volume 1

Research, Development, Test & Evaluation, Defense-Wide - 0400

Fiscal Year (FY) 2011 Budget Estimates

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Defense-Wide
FY 2011 President's Budget
Exhibit R-1
(Dollars in Thousands)

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

Date: 13 Jan 2010

Line No	Program Element Number	Item	Act	FY 2009	FY 2010	FY 2011	Sec
2	0601101E	Defense Research Sciences	01	187,157	205,915	328,195	U
		Basic Research		187,157	205,915	328,195	
10	0602303E	Information & Communications Technology	02	236,531	272,191	281,262	U
11	0602304E	Cognitive Computing Systems	02	122,810	144,236	90,143	U
12	0602305E	Machine Intelligence	02			44,682	U
13	0602383E	Biological Warfare Defense	02	163,993	40,418	32,692	U
18	0602702E	Tactical Technology	02	316,166	248,683	224,378	U
19	0602715E	Materials and Biological Technology	02	238,172	270,207	312,586	U
20	0602716E	Electronics Technology	02	181,519	179,402	286,936	U
		Applied Research		1,259,191	1,155,137	1,272,679	
32	0603286E	Advanced Aerospace Systems	03	38,252	258,278	303,078	U
33	0603287E	Space Programs and Technology	03	226,369	183,477	98,130	U
49	0603739E	Advanced Electronics Technologies	03	192,686	194,094	197,098	U
53	0603760E	Command, Control and Communications Systems	03	297,643	269,198	219,809	U
54	0603765E	Classified DARPA Programs	03	193,690	177,582	167,008	U
55	0603766E	Network-Centric Warfare Technology	03	133,138	138,361	234,985	U
56	0603767E	Sensor Technology	03	182,583	222,866	205,032	U
57	0603768E	Guidance Technology	03	93,720	36,886		U
		Advanced Technology Development (ATD)		1,358,081	1,480,742	1,425,140	
153	0605502E	Small Business Innovative Research	06	78,877			U
161	0605897E	DARPA Agency Relocation	06	27,924	44,812	11,000	U
162	0605898E	Management HQ - R&D	06	53,569	54,842	56,257	U

Exhibit R-1: Total (Direct and Supplementals), as of January 13, 2010 at 10:02:48

Defense-Wide
FY 2011 President's Budget
Exhibit R-1
(Dollars in Thousands)

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

Date: 13 Jan 2010

Line No	Program Element Number	Item	Act	FY 2009	FY 2010	FY 2011	Sec
170	0305103E	Cyber Security Initiative	06	49,865	49,791	10,000	U
		RDT&E Management Support		210,235	149,445	77,257	
		Total Research, Development, Test & Eval, DW		3,014,664	2,991,239	3,103,271	

Exhibit R-1: Total (Direct and Supplementals), as of January 13, 2010 at 10:02:48

Program Element Table of Contents (by Budget Activity then Line Item Number)

Budget Activity 01: Basic Research

Budget Activity 02: Applied Research

Budget Activity 03: Advanced Technology Development (ATD)

Budget Activity 06: RDT&E Management Support

Budget Activity 06: RDT&E Management Support

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Program Element Table of Contents (Alphabetically by Program Element Title)

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Volume 1 Table of Contents

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Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	187.157	205.915	328.195	0.000	328.195	268.459	273.828	279.305	284.891	Continuing	Continuing
BLS-01: *BIO/INFO/MICRO SCIENCES*	39.488	39.541	53.835	0.000	53.835	34.327	35.425	40.925	40.925	Continuing	Continuing
CCS-02: *MATH AND COMPUTER SCIENCES*	33.345	46.558	73.211	0.000	73.211	67.199	77.401	80.501	80.951	Continuing	Continuing
ES-01: *ELECTRONIC SCIENCES*	62.174	57.057	70.193	0.000	70.193	66.503	68.252	62.752	62.752	Continuing	Continuing
MS-01: *MATERIALS SCIENCES*	52.150	62.759	78.456	0.000	78.456	90.430	82.750	85.127	90.263	Continuing	Continuing
TRS-01: *TRANSFORMATIVE SCIENCES*	0.000	0.000	52.500	0.000	52.500	10.000	10.000	10.000	10.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

(U) The Bio/Info/Micro Sciences project will explore and develop potential technological breakthroughs that exist at the intersection of biology, information technology and micro/physical systems to exploit advances and leverage fundamental discoveries for the development of new technologies, techniques and systems of interest to the DoD. Programs in this project will draw upon information and physical sciences to discover properties of biological systems that cross multiple biological architectures and functions, from the molecular and genetic level through cellular, tissue, organ, and whole organisms' levels.

(U) 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.

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

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

(U) 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 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	202.487	226.125	0.000	0.000	0.000
Current President's Budget	187.157	205.915	328.195	0.000	328.195
Total Adjustments	-15.330	-20.210	328.195	0.000	328.195
• Congressional General Reductions		-0.863			
• Congressional Directed Reductions		-36.807			
• Congressional Rescissions	-1.791	0.000			
• Congressional Adds		17.460			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-7.849	0.000			
• SBIR/STTR Transfer	-5.690	0.000			
• TotalOtherAdjustments	0.000	0.000	328.195	0.000	328.195

Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2009	FY 2010
Project: BLS-01: *BIO/INFO/MICRO SCIENCES*		
Congressional Add: *Bio Butanol Production Research*	2.000	0.000
Congressional Add: *Countermeasures to Combat Protozoan Parasites*	0.000	1.600

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2009**	**FY 2010**
Congressional Add Subtotals for Project: BLS-01	2.000	1.600
Project: CCS-02: *MATH AND COMPUTER SCIENCES*		
Congressional Add: *Institute for Information Security*	2.500	0.000
Congressional Add: *Science, Technology, Engineering and Mathematics Initiative*	0.000	1.600
Congressional Add Subtotals for Project: CCS-02	2.500	1.600
Project: ES-01: *ELECTRONIC SCIENCES*		
Congressional Add: *Advanced Photonic Composites Research*	1.280	0.000
Congressional Add: *Laboratory for Advanced Photonic Composites Research*	0.000	1.280
Congressional Add Subtotals for Project: ES-01	1.280	1.280
Project: MS-01: *MATERIALS SCIENCES*		
Congressional Add: *Comparative Genomics for National Security Goals/Infectious Disease Research*	2.000	1.200
Congressional Add: *Institute for Collaborative Sciences Research*	1.200	2.080
Congressional Add: *Advanced Materials Research Institute*	2.400	0.800
Congressional Add: *Hydrogen Fuel Cell Research*	0.000	4.000
Congressional Add: *Solid Oxide Fuel Technology*	0.000	1.000
Congressional Add: *Security Protection using Ballistic CORE Technology*	0.000	3.900
Congressional Add Subtotals for Project: MS-01	5.600	12.980
Congressional Add Totals for all Projects	11.380	17.460

Change Summary Explanation

FY 2009

Decrease reflects Section 8042 rescission of the FY 2010 Appropriation Act, SBIR/STTR transfer and internal below threshold reprogramming.

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FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts offset by congressional adds (as identified above).

FY 2011

Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010

APPROPRIATION/BUDGET ACTIVITY	**R-1 ITEM NOMENCLATURE**	**PROJECT**
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	PE 0601101E: *DEFENSE RESEARCH SCIENCES*	BLS-01: *BIO/INFO/MICRO SCIENCES*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
BLS-01: *BIO/INFO/MICRO SCIENCES*	39.488	39.541	53.835	0.000	53.835	34.327	35.425	40.925	40.925	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Bio Interfaces	6.099	2.707	0.000	0.000	0.000
(U) 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. *FY 2009 Accomplishments:* - Tested theoretical mathematical formulations of the laws of biology on simple systems. - Compared gene regulatory modules involved in the growth and development of plants and animals for similar functionality.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Tested proposed mathematical theory of collective decision making in viruses. *FY 2010 Plans:* - Test theoretical mathematical formulations of the laws of biology on multi-scale systems. - Develop a generalized thermodynamic formalism for biological systems. - Develop theoretical mathematical formulation for rewiring of modules in regulatory pathways in bacterial evolution.					
Preventing Violent Explosive Neurologic Trauma (PREVENT) (U) The Preventing Violent Explosive Neurologic Trauma (PREVENT) program seeks to understand the causes of blast-induced traumatic brain injury, an injury that while previously described in the warfighter population, has been referred to as a potential “hidden epidemic” in the current conflict. PREVENT will use a variety of modeling techniques based on the in-theater conditions to assess the potential traumatic brain injury caused by blast in the absence of penetrating injury or concussion. Research will create a model that can be directly correlated to the epidemiology and etiology of injury seen in returning warfighters, and attempt to determine the physical and physiological underpinnings and causes of the injury. Mitigation and treatment strategies will be formulated based on our new knowledge of blast-induced brain injury with the eventual goal of reducing injury severity across the forces by over fifty percent, improving recovery time, and preventing future injuries. *FY 2009 Accomplishments:* - Examined protection and mitigation strategies that greatly reduce the number and extent of traumatic brain injuries in warfighter population due to explosion. - Continued studies on blast effects as needed to determine underlying physiological causes of blast induced brain injury. - Verified causes of blast brain injury through observations in warfighter population. - Assessed injurious role of electrical discharge from detonation of cased munitions on central nervous system.	8.839	4.325	4.775	0.000	4.775

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Assess the effect of commonly available pharmaceuticals in both acute and chronic mitigation of blast brain injury symptoms. - Validate diagnostic criteria for assessment of mild to severe blast brain injury. - Test and validate fabricated device strategies to ensure that they appropriately mitigate the effects of blast brain injury. *FY 2011 Base Plans:* - Develop devices and diagnostic platforms for blast brain injury in theater as needed. - Determine the physiological effects of blast on brain tissue as well as short-term and long-term behavior and cognition in non-human primates. - Coordinate with military medical community and Services as needed to ensure technology reaches adoption. - Investigate the long-term effects of exposure to blast on warfighters following return from deployment.					
Biological Adaptation, Assembly and Manufacturing (U) The Biological Adaptation, Assembly and Manufacturing program will examine 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	4.500	7.347	9.217	0.000	9.217

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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. Applications to Defense systems include the development of chemical and biological sensors, and improved battlefield survivability of the warfighter. *FY 2009 Accomplishments:* - Developed complete mathematical model for fracture putty/bone biomechanics. - Developed fracture putty material which approximates the mechanical properties and internal structure of natural bone. - Demonstrated mechanical properties of fracture putty for in vitro model of bone fracture. - Identified newly discovered bacteria with unique enzymatic activity on crystalline cellulose. *FY 2010 Plans:* - Develop novel resorbable wet adhesives with the mechanical properties of natural bone, for inclusion into fracture putty formulation. - Demonstrate fracture putty in small animal model of bone fracture. - Initiate large animal studies of fracture putty for bone fracture repair. - Identify candidate fundamental mechanisms for controlling antibody stability and affinity. - Demonstrate the ability to produce an antibody with thermal stability from room temperature up to 60 degrees Celsius. - Demonstrate the ability to produce an antibody with selectable affinity as measured by a binding constant (KD=dissociation constant) of 10 to the negative eighth power. *FY 2011 Base Plans:* - Demonstrate fracture putty in large animal model of bone fracture, with independent validation. - Initiate expanded large animal studies of fracture putty in preparation for human clinical trials. - Combine identified antibody stability and affinity capabilities into a single “Master Antibody Molecule” that exhibits two target metrics against a single biological threat agent.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Provide a minimum of 2 grams of the identified "Master Antibody Molecule" for independent testing by a Government laboratory. - Incorporate the identified "Master Antibody Molecule" into an existing biosensor platform and demonstrate advanced capability in terms of robustness and potential for multiplexing.					
Nanostructure in Biology (U) The Nanostructure in Biology program will investigate the nanostructure properties of biological materials to better understand their behavior and accelerate their exploitation for Defense applications. This new information about biomolecules and complex cellular systems will provide important new leads for the development of threat countermeasures, biomolecular probes and motors, and neuromorphic sensory systems. This program will also develop approaches to mathematically predict a priori, the structure of biological materials, especially proteins, based on the desired performance. This will enable the rapid design of new biosensors against previously unknown threats and the design of advanced catalysts based on biological activity to produce new materials of interest to DoD (e.g., tailored explosives). The program will also create technology to reliably integrate nanoscale and microsystems payloads on insects that will extract power, control locomotion, and also carry DoD relevant sensors. *FY 2009 Accomplishments:* - Created a functional model of the mammalian object recognition pathway that is biologically valid and suitable for translation to algorithm development. - Optimized Micro Electro Mechanical Systems (MEMS) components for locomotion control, communications and power generation to consume less power and to reduce size, weight and cost. - Designed two protein-protein binding pairs with binding constants below one hundred nanomolar. - Extended catalytic activity of de novo designed enzymes to ten million for known chemistries.	10.500	5.928	2.400	0.000	2.400

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Discover methods for precise flight control use in combinations of MEMS techniques originating in the previous fiscal year. - Develop neural interfaces to insect sensors to compliment electronic sensors. - Develop a protein that inhibits the activity of influenza by preferential binding. - Design de novo inhibitory protein of smallpox. *FY 2011 Base Plans:* - Exploiting protein design tools, modify the anthrax capsule-depolymerizing enzyme to increase stability in serum two-fold.					
Human Assisted Neural Devices (U) The Human Assisted Neural Devices program will develop 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. This will require 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 revolutionary 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. *FY 2009 Accomplishments:* - Identified memory neural codes that are specific to critical work related tasks, enabling possible potential memory restoration in a brain-wounded warfighter. - Developed new types of neural-electrical interfaces capable of continuous recording of neural patterns.	5.550	15.134	18.943	0.000	18.943

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Explored mechanisms of information transfer between disparate regions of the brain during sensorimotor tasks. *FY 2010 Plans:* - Identify neural processes for encoding short- and long-term memory in primates during a complex motor task. - Build hardware and software to implement pattern extraction and inter-individual verification of homogeneity of patterns between primates. - Create an interface that enables performance of a complex motor/sensory task through an assistive device without using either motor or sensory function. - Determine task performance changes resulting from learning and plasticity through observation of the development of functional networks in the primate and rodent brain over time. - Construct algorithms and methods capable of more accurately describing and estimating neural signals from limited data. *FY 2011 Base Plans:* - Assess ability of primate to retain short-term memory encoding following simulated injury through use of neural codes. - Determine potential for long-term memory encoding assisted through use of neural codes in primates with long-term memory deficit. - Identify homogeneity of neural codes involving long-term memory between primates conducting similar long-term memory tasks. - Map dynamic functional motor and sensory networks and develop methods for characterizing brain-wide sensory/motor tasks. - Determine the role of specific neural pathways in a complex motor/sensory task through perturbation of existing and defined functional networks in primate and rodent experiments. - Investigate stimulation of sensory networks to determine how sensory information is encoded and utilized by the brain.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Improve learning and performance of primates during complex sensorimotor tasks through robust decoding of neural activity. - Develop models of neural behavior that more accurately approximate biological signaling. - Fabricate neural interfaces capable of stimulating and recording multiple channels of neural activity at distributed sites throughout the brain.					
Mathematics of the Brain (MoB) (U) The Mathematics of the Brain program will develop a powerful new mathematical paradigm for understanding how to model reasoning processes for application to a variety of emerging DoD challenges. This will require constructing a novel mathematical architecture for a biologically consistent model of thought that moves beyond the state of the art to allow the ability to learn and reason. The program will also 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 2009 Accomplishments:* - Proposed a mathematical model of the brain that is consistent and predictive with brain function, rather than merely biologically inspired. - Leveraged recent advances in neuroscience and mathematics to explore an integrated theory that overcomes the difficulties present in traditional approaches, such as artificial intelligence and artificial neural networks. *FY 2010 Plans:* - Investigate a new mathematical theory of compressive measurement.	2.000	2.500	6.000	0.000	6.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Develop a new comprehensive theory to exploit information in signals. - Exploit the new theoretical framework together with novel forms of prior knowledge in order to enable optimal information gathering from sparse signal sampling. - Demonstrate the utility of new theory via improvements to applications in communications, signals intelligence, and imaging.					
Physics in Biology (U) Understanding the fundamental physical phenomena that underlie biological processes and functions will provide 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. Using quantum theoretical models and mathematical algorithms, new understanding of quantum effects will enable exploitation in existing abiotic applications. This includes exploiting manifestly quantum mechanical effects that exist in biological systems at room temperature to develop a revolutionary new class of compact high sensitivity sensors. *FY 2011 Base Plans:* - Develop a quantum theoretical model of postulated non-trivial quantum mechanical effects in specific biological systems. - Experimentally verify that the biological system exploits the effect at room temperature. - Formulate testable predictions for impact of perturbations to the biological system.	0.000	0.000	6.000	0.000	6.000
Scaffold-Free Tissue Engineering (STF) (U) The objective of the Scaffold-Free Tissue Engineering program is the development of tissue and organ construction platforms that utilize non-contact forces such as magnetic fields to achieve desired tissue architectures. The STF-developed platforms would circumvent current limitations by removing the use of a material scaffold and providing simultaneous control of multiple cell/tissue types for the	0.000	0.000	6.500	0.000	6.500

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** BLS-01: *BIO/INFO/MICRO SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
construction of large, complex tissues in vitro and in vivo. The program will provide a paradigm shift versus current tissue engineering approaches using permanent or resorbable protein scaffolds. Such scaffolds are limited to construct sizes of 2-3 square millimeters due to oxygen and nutrient diffusion limitations, which severely limits the complexity of the tissue(s) constructed to a single cell type. In vivo, scaffold-based tissue engineering has not achieved anticipated widespread application due to the inability to properly control the cellular response to the implanted scaffold and due to difficulties in controlling the scaffold integrity/degradation. The initial STF program component is the development of non-contact cell positioning procedures. The fundamental goal is to correctly position target cells in a desired pattern for a sufficient period of time to allow the cells to synthesize their own scaffold. Potential approaches include magnetic field and/or dielectrophoretic positioning. Critical to early programmatic achievement is the capability to position at least two cell types through the identification of cellular magnetic taggants, characterization of cellular dielectric characteristics and determination of application dynamics (e.g., duration, cycles, amplitude) to achieve multicellular tissue construction in vitro. A potential transition to an in situ application would allow wound site reconstruction without the need to implant scaffold material. Construction of a stable implantable skeletal muscle construct (5 cm3) with vascular and neural components will be the final programmatic demonstration. *FY 2011 Base Plans:* - Identify non-contact approaches such as magnetic fields and dielectrophoresis that provide cell positioning in three dimensions without negatively impacting cell viability. - Demonstrate in vitro construction of multicellular tissue using one or more non-contact cell positioning approaches. - Demonstrate survival and functional implantation of a 2 cubic centimeter multicellular skeletal muscle scaffold-less construct into an appropriate in vivo model. - Develop cellular placement instrumentation for in vivo implementation of scaffoldless tissue construction.					
Accomplishments/Planned Programs Subtotals	37.488	37.941	53.835	0.000	53.835

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Bio Butanol Production Research *FY 2009 Accomplishments:* - Investigated bio-butanol production capabilities.	2.000	0.000
Congressional Add: Countermeasures to Combat Protozoan Parasites *FY 2010 Plans:* Initiate research to develop countermeasures to combat protozoan parasites.	0.000	1.600
Congressional Adds Subtotals	2.000	1.600

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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CCS-02: *MATH AND COMPUTER SCIENCES*	33.345	46.558	73.211	0.000	73.211	67.199	77.401	80.501	80.951	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project supports scientific study and experimentation on new computational models and mechanisms for reasoning and communication in complex, interconnected systems in support of long-term national security requirements. The project is exploring novel means of exploiting computer capabilities; practical, logical and heuristic reasoning by machines; development of enhanced human-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 Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Foundational Computer Science	2.344	5.612	9.450	0.000	9.450
(U) The Foundational Computer Science program supports research in broad areas of computational science having the potential for revolutionary advances in performance and other relevant metrics above and beyond extrapolations of current approaches. The research will yield significant advances in networking, software, hardware, and computational systems in a world where computing devices are ubiquitous and heterogeneous. The Foundational Computer Science program is addressing the need for highly reliable and trustworthy mission-critical information systems, including both software and hardware. New programming languages that facilitate parallel programming on multi-core processors, scalable formal methods, clean-slate execution models, co-design approaches for hardware and software, and other techniques will be used to guarantee the security, reliability, performance and robustness of a design while also reducing its complexity and cost. Interest in communications and sensor networks addresses challenges related to dynamic heterogeneous multi-modal networks. The Foundational Computer Science program will also address problems that are inherently computationally					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
complex and, in many cases, intractable. For example, the game of Go provides an ideal platform for creating the heuristic approaches and tools necessary to solve problems that typically require either enormous computer resources or simplification that sacrifices accuracy. The resulting technologies will be candidates for future command and control decision aids that can assess the consequences of specific actions and strategies to better predict future results in applications such as irregular warfare, cyber-security, supply chain optimization, networking and robotics. *FY 2009 Accomplishments:* - Assessed the potential for the recently developed Upper Confidence Tree (UCT) algorithm to search trees with high branching factor. - Developed features for spatial description of board position for the game of Go. *FY 2010 Plans:* - Develop improved methods of planning and reasoning to calculate Go best-next-move hypotheses from board positions and use such hypotheses to develop a highly targeted search. - Develop methods for visualization to determine similarity and differences in positional configurations. - Create models for multiple, diverse, heterogeneous networks with new degrees of dynamics, changing network characteristics, and behavior. *FY 2011 Base Plans:* - Continue development of methods for visualization to determine similarity and differences in positional configurations. - Develop algorithms to introduce intelligence to massive search problems. - Combine algorithmic approaches to Go optimization with heuristic assessment of the value of information to introduce a new area of research in machine learning and planning. - Develop and apply new mathematical descriptions and characterizations that unify disparate network types and that address the dynamics, interactions, information flow, stability, and other critical aspects.					
Foundational Machine Intelligence*	0.000	3.681	9.000	0.000	9.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
*Previously in Foundational Computer Science. (U) The Foundational Machine Intelligence program is supporting research on the foundations of artificial intelligence and machine learning and reasoning. One focus is on techniques that can efficiently process and “understand” massive data streams. Deeply layered machine learning engines will be 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 examines the human aspects of computing, with interest in collaboration, interaction and information exchange; non-symbolic representation/reasoning paradigms based upon a universal “cortical” algorithm; unmanned vehicles and intelligent agents that generate and manage their own goals within human-described mission constraints; and modeling of human language acquisition by associating words with the real-world entities perceived through multiple modes of sensory input. *FY 2010 Plans:* - Create machine learning techniques that can assimilate huge amounts of data by creating rich representations of the input data and applying them to multiple applications. - Construct a single, general-purpose algorithm which could start with zero knowledge of its environment, and then grow to represent the structure latent in that environment. *FY 2011 Base Plans:* - Create parameter-free methods that learn appropriate representations starting from raw inputs with a single architecture and learning algorithm. - Enable machines to incorporate sensory information in a robust way to improve situational awareness.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate multiple general-purpose learning algorithms and characterize their performance and operational constraints. - Develop algorithms for automated problem recognition and goal management and create a language for computer-interpreted mission descriptions.					
Information Theory for Wireless Mobile Ad Hoc Networks (ITMANET)* * Previously in Foundational Computer Science. (U) The Information Theory for Wireless Mobile Ad Hoc Networks (ITMANET) program is creating an information theory for ad hoc mobile wireless networking in the absence of wired infrastructure. Issues being addressed include 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 2009 Accomplishments:* - Determined the multicast capacity region for large wireless MANETs. - Developed distributed algorithms that enable “interference alignment”, a technique that achieves increased wireless network capacity in the high signal-to-noise ratio regime. - Developed capacity-achieving routing protocols for multi-hop ad-hoc networks with highly mobile nodes that move arbitrarily. *FY 2010 Plans:* - Predict performance in terms of throughput-delay-reliability for modest-sized MANETs with and without feedback.	1.361	3.271	5.646	0.000	5.646

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop upper-bounding techniques that go beyond the classical bounds and inequalities for MANETs. *FY 2011 Base Plans:* - Predict performance in terms of throughput-delay-reliability for any MANET realization. - Develop protocols for interference alignment architectures that can approach the end-to-end MANET transmission capacity limit. - Develop a generalized theory of rate distortion and network utilization.					
Centers of Excellence for Computational Science and Engineering (COECSE) (U) The Centers of Excellence for Computational Science and Engineering (COECSE) will address the most difficult and fundamental challenges facing computing today. Computing has reached three walls of security, energy (power consumption) and programmability that cannot be overcome by traditional, evolutionary techniques. Security and energy-efficiency are difficult roadblocks for all current architectural approaches. Revolutionary new architectures, ranging from microprocessors, memory and interfaces to full-scale systems, are needed if we are to sustain the rate of advancement to which we have become accustomed. Languages that make programming current and future multi-core processors far more tractable for the average application developer are needed if we are to reap the benefits of emerging processor paradigms such as massive multi-core. The current approach to security, which attempts to retrofit security onto an evolving, imprecisely known, and increasingly complex (even non-deterministic) COTS infrastructure, is ad hoc and ineffectual – more systematic approaches are required. (U) Traditionally, computing has sought to overcome these three walls separately, with security, processing architectures, and programming languages developed in isolation and applied independently. The Centers of Excellence Program for Computational Science and Engineering will create research centers engaging academics and industry to explore and develop a more holistic approach to breaking down these walls. Examples of the types of research of interest include co-	0.000	0.000	4.000	0.000	4.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
design approaches for hardware and software; parallel abstractions and new methods for expressing parallelism; software development environments for rapidly creating energy efficient embedded systems; computing components that have security “baked in” from the start for use at key points in the hardware and software stacks; provably secure clean-slate execution models; novel architectures for logic, memory, and data access to support secure execution; formal automated proof tools for security throughout the execution model; self-aware and learning capabilities to manage security at run-time; coordinated development of resiliency techniques (including detection and correction, fail-in-place self-healing, and learning); and new safe/secure computer languages and compilers. *FY 2011 Base Plans:* - Identify and develop new and holistic approaches to enhancing the security, energy-efficiency, and programmability of computing systems.					
Training for Adaptability (U) The Training for Adaptability program will develop adaptable environments and experiences to increase diversity and fidelity of leadership training. *FY 2011 Base Plans:* - Formulate an initial framework for the examination of different notions of leadership within complex social systems and environments. - Create leadership models that planners can use to evaluate alternative actions in human terrain problems and to develop effective commander’s intent statements.	0.000	0.000	5.000	0.000	5.000
Computer Science Study Group (CSSG) (U) 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	9.890	10.400	10.550	0.000	10.550

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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 2009 Accomplishments:* - Developed a novel agent based simulation environment that allows persons without computer programming expertise, and warfighters on the ground, air or sea down to the lowest unit levels in particular, to develop realistic new training scenarios quickly and on demand. - Developed fundamental algorithms with provable guarantees of correctness and efficiency to enable effective learning from incomplete data and data corrupted with noise. - Explored bio-inspired computing emphasizing evolutionary computation and artificial neural networks (ANNs) to solve difficult real world tasks such as autonomous guidance of vehicles. - Developed new approaches for management of network security, authentication, mobility, and hand-off management with emphasis on self-organizing wireless networks in a battlefield environment. *FY 2010 Plans:* - Continue to identify and explore new computer science challenges that, when addressed, will yield extraordinary advances for DoD applications. - Develop high-performance parallel computing and interactive computer graphics. - Develop natural language processing techniques to enable substantial improvements in machine translation and paraphrasing, detection of deviations from normalcy and behavioral changes, and the management, sorting and accessing of textual data. - Develop reliable low-power embedded systems for continuous information gathering, access and communication; thermal and power consumption modeling for integrated circuit design. *FY 2011 Base Plans:* - Continue to identify and explore new computer science challenges that, when addressed, will yield extraordinary advances for DoD applications.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Exploit synergies in hardware/software co-design to enable transformational advances in reliability and security in the challenging low-power, low-memory, real-time operational environment of embedded computing systems. - Develop novel and highly-economical surface reconstruction and computer graphic rendering algorithms to enable visualization of and interaction with complex battlefield and other simulations in real time. - Develop novel machine learning algorithms that provide not only better predictive power, but also better explanatory power via exploitation of Bayesian statistics (the concept of probability) to leverage prior information and advanced techniques for fusion of heterogeneous information from multiple sources.					
Programmable Matter (U) The Programmable Matter program will develop a new functional form of matter, constructed from mesoscale particles that assemble into complex 3-Dimensional (3-D) objects upon external command. These objects will exhibit all of the functionality of their conventional counterparts and ultimately have the ability to reverse back to the original components. *FY 2009 Accomplishments:* - Built a mathematical model that theoretically confirms a viable procedure for constructing macroscopic 3-D solid objects with functional properties that have real world use. - Demonstrated externally-directed assembly of distinct macroscopic 3-D solids. *FY 2010 Plans:* - Optimize Programmable Matter properties. - Demonstrate interlocking/adhesion of mesoscale particles to create bulk matter. - Demonstrate reversibility.	4.000	3.094	0.000	0.000	0.000
Young Faculty Award	8.500	14.000	14.500	0.000	14.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The goal of the Young Faculty Award program is to encourage new faculty members of academic research institutions with innovative ideas and concepts to participate in sponsored research programs that can provide revolutionary capabilities to future defense systems. The program will also help innovative researchers better understand the needs of the DoD and interest them in working on problems with a defense relevance. The initial phase of this program focuses on speculative technologies for greatly enhancing microsystems technologies and in the development of ideas and concepts that can lead to focused defense research programs and associated development activities to deliver a compete technology. Current activities include revolutionary advances in physics, materials, and devices to enable breakthroughs in electronics, photonics, micro and nano electro mechanical systems (MEMS/NEMS), architectures, and algorithms. *FY 2009 Accomplishments:* - Initiated activities for research of new concepts for enhancing microsystem technologies. - Developed methodology for improving interactions between sponsored researchers and defense technologists. *FY 2010 Plans:* - Continue and initiate new activities for research of enhancements and new concepts for microsystem technologies. - Optimize approaches for obtaining maximum benefit from sponsored efforts. *FY 2011 Base Plans:* - Continue and initiate new activities for research of enhancements and new concepts for microsystem technologies. - Establish transition approaches for appropriate technologies and research activities to enhance development activities.					
Computer Science Futures/Science, Technology, Engineering, and Mathematics Research Outreach*	2.000	2.000	6.665	0.000	6.665

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
*Formerly High School Science Study Group/CS Futures. (U) The DARPA Grand and Urban Challenges inspired a number of high school-age students and exposed them to the rewards of a research career. The future of DoD research depends on the continuing engagement of these students in science- and technology-related fields. An offshoot of the Computer Science Study Group program, the Computer Science Futures program will fund efforts to identify the computer science interests of high school students, and involve them in high-level research at the high school level. In addition, the Computer Science, Science, Technology, Engineering, and Mathematics Research program will develop educational practices and programs that capture the scientific and technical interests of middle and high school students through compelling projects that require computer science, science, technology, engineering, and mathematics. *FY 2009 Accomplishments:* - Continued to engage high school study groups to work on selected ideas. - Continued evaluation of new potential ideas, including human computer interactions, computational models of environmental adaptation, and automated evaluation of physical function for applications in rehabilitation medicine. *FY 2010 Plans:* - Continue to engage high school study groups to work on selected ideas. - Continue evaluation of new potential ideas, including human computer interactions, computational models of environmental adaptation, and automated evaluation of physical function for applications in rehabilitation medicine. - Initiate programs that capture the scientific and technical interests of middle and high school students through compelling projects that require computer science, science, technology, engineering, and mathematics.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Continue ongoing outreach and involvement of high school students in Computer Science research to increase excitement about solving important problems using technology. - Complete transition to industry and/or other partners thus establishing a self-sustaining program to encourage students to enter the Computer Science field. - Execute programs that capture the scientific and technical interests of middle and high school students through compelling projects that require computer science, science, technology, engineering, and mathematics.					
Focus Areas in Theoretical Mathematics (FAThM) (U) The Focus Areas in Theoretical Mathematics (FAThM) program aims to foster major theoretical breakthroughs in pure mathematics whose potential for long-term defense implications is high. By supporting closely integrated and concentrated collaborations among small numbers of leading experts, FAThM will pioneer 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 2009 Accomplishments:* - Established and exploited new relations between number theory and symmetry groups of fundamental particles. - Tied advances in pure mathematics to defense applications in cryptography, quantum sciences, materials, and nano-level structures. *FY 2010 Plans:* - Establish and exploit new relations between topology and symmetry groups of fundamental particles. - Establish and exploit new relations between the analytic foundations of symmetry and algebraic computation.	1.350	1.400	2.400	0.000	2.400

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Establish and exploit new relations between differential geometry, quantum field theories, and infinite dimensional global analysis. - Establish and exploit new relations between generalized homology theories and partial differential equations.					
Fundamental Laws and Limits of Cyber Security (U) Based on advances from the Foundational Computer Science program, the Fundamental Laws and Limits of Cyber Security program seeks to establish a framework of fundamental laws and limits governing cyber security, which enables pro-active approaches to the complex task of making cyber systems secure. Research in this area focuses on creating a fundamental theory of security-oriented system complexity and a methodology for applying the theory to practical challenges of system security for systems ranging from simple programs on a single computer to large-scale distributed applications. Currently there is little understood on how to measure the efficiency of the huge variety of ad-hoc methods for improving system security and on how to know which of these methods should be used in each particular case. Therefore, the design, development, and integration of secure cyber systems are a continuous, evolving process. U.S. military computing systems are continuously vulnerable to malicious cyber attacks. This program's framework provides military planners the guidance on pro-active decision-making in system design, implementation, and deployment. The key steps in this effort include: 1) development of complexity-based metrics that would directly measure how hard it would be for system developers/integrators to create a system that would be free of security holes; 2) development of a security-oriented complexity hierarchy; 3) development of the requisite theory that would help explain how the system design and implementation affects the metrics; and 4) creation of a methodology for applying the theory to practical systems.	0.000	0.000	4.000	0.000	4.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Create new complexity-based metrics that would directly measure how hard it would be for system developers/integrators to create a system that would be free of security holes. - Define a security-oriented complexity hierarchy. - Initiate development of the requisite theory that would help explain how the system design and implementation affects the metrics.					
23 Mathematical Challenges (U) This program aims 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 2009 Accomplishments:* - Developed advances in stratified Morse Theory and metric, algebraic, and hyperbolic geometries to investigate complex fluid flow. - Built and exploited deep mathematic dualities between Complex Algebraic Geometry, Algebraic and Geometrical Topology, Fourier Analysis, Geometrical Combinatorics, Theory of Oscillatory Sums, and Analytic Number Theory. *FY 2010 Plans:* - Develop integrated approaches merging analysis and algebra to create new polynomial optimization algorithms. - Build and exploit deep mathematic techniques in combinatorics (the study of discrete objects) and geometry to develop new capabilities in rigidity theory for diverse applications including protein folding. - Develop theoretical guidelines for filtering multi-scale turbulent signals, incorporating new theories of data assimilation, including sparse observations.	1.400	1.500	2.000	0.000	2.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop a theoretical analysis of idealized data assimilation problems in an identified complex system. *FY 2011 Base Plans:* - Develop the high-dimensional mathematics needed to accurately model and predict behavior in large-scale distributed networks that evolve over time occurring in communication, biology, and the social sciences. - Develop new mathematics for constructing optimal globally symmetric structures via the process of nanoscale self-assembly. - Develop practical computational strategies for cheaper systematic treatment of model error in complex systems in high dimensions.					
Accomplishments/Planned Programs Subtotals	30.845	44.958	73.211	0.000	73.211

	FY 2009	FY 2010
Congressional Add: Institute for Information Security *FY 2009 Accomplishments:* - Completed information security initiatives.	2.500	0.000
Congressional Add: Science, Technology, Engineering and Mathematics Initiative *FY 2010 Plans:* - Initiate research in the areas of science, technology, and engineering.	0.000	1.600
Congressional Adds Subtotals	2.500	1.600

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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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
ES-01: *ELECTRONIC SCIENCES*	62.174	57.057	70.193	0.000	70.193	66.503	68.252	62.752	62.752	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Semiconductor Technology Focus Centers	20.450	20.400	20.000	0.000	20.000
(U) The Semiconductor Technology Focus Centers research program is a collaborative effort between the Defense Advanced Research Projects Agency (DARPA), the Office of the Deputy Undersecretary of Defense for Science & Technology (DUSD/S&T), and the Microelectronics Advanced Research Corporation (MARCO) which will establish new Focus Centers in "Materials, Structures & Devices" and in "Circuits, Systems & Software" at U.S. Institutions of Higher Education. The Focus Centers will concentrate research attention and resources on a discovery research process to provide radical innovation in semiconductor technology that will provide solutions to barrier problems in the path of sustaining the historical productivity growth and performance enhancement of semiconductor integrated					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
circuits. The overall goal of this collaborative effort between the Department of Defense and industry is to sustain the unprecedented four decades of uninterrupted performance improvement in information processing power. *FY 2009 Accomplishments:* - Developed novel device fabrication and integration approaches for deeply scaled transistors and architectures for high performance mixed signal circuits for military needs. - Developed concepts and validation methods in one or combinations of the following areas: electronics, photonics, micro-electro-mechanical systems (MEMS), architectures and algorithms. *FY 2010 Plans:* - Continue to develop innovative approaches to the design and fabrication of scaled devices, circuits, and microsystems within multi-investigator based research consortia. *FY 2011 Base Plans:* - Continue to leverage industry funding for efforts and maintain formal and informal coupling and industrial research for development and transition of technologies. - Transition innovative concepts developed with the university program to provide novel capabilities for DoD microelectronics systems.					
Quantum Entanglement Science and Technology (QuEST) (U) The Quantum Entanglement Science and Technology (QuEST) program will explore the research necessary to create new technologies based on quantum information science. Technical challenges include loss of information due to quantum decoherence, limited communication distance due to signal attenuation, 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	14.804	10.669	15.946	0.000	15.946

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
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 2009 Accomplishments:* - Developed novel approaches to improving decoherence times. - Devised full characterization and manipulation of entangled quantum systems. - Formulated novel quantum algorithms. *FY 2010 Plans:* - Continue fundamental research in the area of Quantum Information and work towards program goals. - Develop novel approach to improving decoherence times. - Demonstrate novel quantum algorithms. *FY 2011 Base Plans:* - Continue fundamental research in the area of Quantum Information and work towards program goals. - Demonstrate full characterization and manipulation of entangled quantum systems.					
N/MEMS Science and Focus Centers (U) The goal of the N/MEMS Science and Focus Centers program is to support the development of an enhanced fundamental understanding of a number of important technical issues critical to the continuing advance of nanoelectromechanical systems (NEMS) and microelectromechanical systems (MEMS) technologies and their transition into military systems. The basic research work to be conducted under the program is responsive to recognized challenges in a comprehensive range of technical areas pertinent to future Department of Defense (DoD) needs. Industrial cost sharing is an important element of the overall effort.	9.423	7.028	4.903	0.000	4.903

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed MEMS enabled reconfigurable electronics. - Developed ultra-high Q (energy ratio) nanoresonators. *FY 2010 Plans:* - Continue to improve the efforts for each of the eleven centers. - Incorporate new N/MEMS fabrication methods (i.e., self-assembly). - Commence integration of MEMS power supplies. *FY 2011 Base Plans:* - Finalize substantial scientific and technical interactions among the university and industrial partners. - Achieve a dynamic process for focusing center research evolution. - Develop a methodology for adding, deleting, and/or modifying research directions within the center.					
Nanoscaled Architecture for Coherent Hyper-Optic Sources (NACHOS) (U) The objective of the Nanoscaled Architecture for Coherent Hyper-Optic Sources (NACHOS) program is to demonstrate sub-wavelength semiconductor lasers by leveraging recent developments in reduced dimensionality and advanced feedback concepts. The specific program goal is 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 will enable 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 expected to be 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 2009 Accomplishments:* - Demonstrated novel heterostructures capable of gain. - Established minimum Q factor for laser threshold.	3.555	3.117	1.725	0.000	1.725

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Demonstrate sub-wavelength lasers. - Determine threshold gain under injection. *FY 2011 Base Plans:* - Demonstrate room temperature sub wavelength laser operating at 1.55 microns in continuous mode.					
Tip-Based Nanofabrication (TBN) (U) The Tip-Based Nanofabrication (TBN) program will develop the capability to use Atomic Force Microscope (AFM) cantilevers and tips to controllably manufacture nano-scale structures such as nanowires, nanotubes, and quantum dots for selected defense applications such as optical and biological sensors, diode lasers, light emitting diodes, infrared sensors, high-density interconnects, and quantum computing. *FY 2009 Accomplishments:* - Demonstrated nanofabrication process using a single-tip structure and associated tooling. *FY 2010 Plans:* - Fabricate a multi-tip array (5 tips) for parallel manufacturing. - Demonstrate a repeatable tip-based process and manufacturing capability. *FY 2011 Base Plans:* - Fabricate a 30-tip array and associated tool and manufacturing process. - Demonstrate operation of multi-tip arrays over extended periods of time for use in manufacturing complex components. - Demonstrate precision and control of the process and functionality of the resulting structures.	10.662	10.424	10.100	0.000	10.100
Optical Radiation Cooling and Heating in Integrated Devices (ORCHID)*	0.000	2.000	2.000	0.000	2.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
*Formerly Quantum OptoMechanics Integrated on a Chip. (U) The objective of the Optical Radiation Cooling and Heating in Integrated Devices (ORCHID) program is to leverage advances in Photonics and Micro fabrication to develop integrated chips capable of exploiting quantum optomechanical applications. Although light is usually thought of as carrying energy but relatively little momentum, light confined to a high-finesse cavity can exert significant force on the cavity mirrors. When the mirror is allowed to vibrate by coupling it to a mechanical (spring-like) system, energy can be transferred between coupled optomechanical resonators. Depending on the detuning of the cavity, one can obtain either damping (cooling) or amplification (heating) of the mirror motion. Notable achievements in this field are the demonstration of mirror cooling (damping of the internal degree of motion) to sub-Kelvin (6 mK) temperatures and demonstration of radiation driven high-Q, high-frequency (1 GHz) oscillators. With sufficiently high cavity finesse and Q's of the mechanical system, it is possible to reach a regime in which the mirror motion is no longer thermally limited. Instead, it becomes limited by the quantum mechanical radiation pressure force. Once this limit is reached, it is possible to take advantage of quantum mechanical effects without having to cool the system. It is anticipated this will result in a new generation of mass-sensing devices and ultra high-Q, high-frequency resonators controlled by light. In optical systems, it will be possible to efficiently squeeze light beyond the standard shot-noise limit producing light sources for infrared detection and quantum information applications. *FY 2010 Plans:* - Demonstrate resonant frequency of 10 megahertz (MHz). - Demonstrate Mechanical Q of 1x10^6. *FY 2011 Base Plans:* - Demonstrate cavity finesse of 1x10^5. - Demonstrate mirror effective mass of 1 nanogram. - Demonstrate resonant frequency of 100 MHz.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate Mechanical Q of 1x10^7.					
Centers for Integrated Photonics Engineering Research (CIPhER)	0.000	2.139	8.000	0.000	8.000

(U) The Centers for Integrated Photonics Engineering Research (CIPhER) program will explore and enhance 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 wider application range than electronics, including such areas as imaging, energy conversion, signal processing, and computing. The rise of integrated photonics as a viable, practical technology, combined with the utility of integrated photonics to many applications, is slated to result in a more rapid transition of basic photonics research to system applications of importance to the Department of Defense. As such, photonics research that is supported by organizations with both fundamental and commercial interests is ideally suited to fostering the growth of the nation’s integrated photonics industry. The CIPhER program will therefore use a government/industrial cost-share funding model to foster the next generation of fundamental university-based photonics research. The CIPhER program is directed toward achieving this objective through the establishment of collaborative theme-based focus centers. Focus centers will be comprised of university-led teams, with industrial partners, engaged in long-term basic research of photonic materials, devices, and microsystems.

FY 2010 Plans:
- Initiate the development and investigation of new integrated photonics concepts for application to microsystems in: Imaging Science and Technology, Energy Conversion and Manipulation, Chip-scale Signal Processing and Computing, and Chemical/Biological Sensing and Processing.

FY 2011 Base Plans:
- Exploit scaling and enhanced fabrication techniques to refine and continue development of novel Integrated Photonics concepts for the range of application domains.

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Begin to transfer (through direct industrial collaborative interactions) those elements that are ready for further development toward applications.					
Molecular Photonics (MORPH) (U) The Molecular Photonics (MORPH) program explored large dendritic and other highly branched organic molecules that offered great potential for active photonic applications. Three-dimensional molecular structures and shapes can be engineered to orient and immobilize optically active substituents to achieve much higher electro-optic activity than with traditional polymer systems. The ability to engineer molecular structure, shape, energy transport, and chemical composition offers the potential for distinct electronic energy level engineering without the traditional semiconductor crystal lattice. Potential applications include: direct conversion of sunlight to power (“optical antenna”), inversion-less lasers and electromagnetically induced transparency (coherent organic emitters, and slow light materials), high performance photorefractive materials for signal processing and holographic memory, optical limiters and saturable absorbers as well as high performance modulators. *FY 2009 Accomplishments:* - Demonstrated a very high speed (100 gigahertz) polymetric electro-optic (EO) modulator. - Demonstrated organic materials for building ultra-high speed EO modulators. - Developed tailored organic materials as high-efficiency optical limiters in regions of the spectrum relevant to military sensor protection.	2.000	0.000	0.000	0.000	0.000
Breakthrough Biological and Medical Technologies (U) This program seeks to yield revolutionary advances across several key areas of biology and biomedical technologies of critical importance to the DoD. The overarching principle is to apply microsystem technology (electronics, microfluidics, photonics, micromechanics, etc.) to create leapfrog advances ranging from manipulation of single cells through soldier-worn protective and diagnostic instruments. Microsystem technologies have reached a state of maturity that they can be deployed as enablers to solving complex problems, the biological applications being particularly high-leverage.	0.000	0.000	7.519	0.000	7.519

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
On the cell-level of the scale, the aim is to be able to increase by several decades the speed with which we sequence, analyze and functionally edit cellular genomes. With microsystem approaches, a prime goal is to be able to address large populations of cells, select as few as one, capture it, make specific edits to its DNA, and examine or replicate the cell as needed. Such capability will be applicable to a wide variety of problems including biological weapons countermeasures and understanding the underpinnings of human cancers. At an intermediate scale, new insights into the interactions of photons with the nervous system tissues of mammals will allow the development of mm-scale microphotonic implants that have the potential to restore sensory and motor function to individuals with traumatic spinal injury, for example. On the other end of the size scale, a primary goal is to apply microsystem techniques to soldier-protective biomedical systems. One example is an in-canal hearing protection device that will provide enhanced hearing capabilities in some settings, but be able to instantly muffle loud sounds of weapons fire. This one example will improve inter-personnel communications and at the same time drastically reduce the incidence of hearing loss in combat situations. For these examples and many more, the goal is to bring exceptionally potent technical approaches to bear on biological and biomedical applications where their capabilities will be significant force multipliers for the DoD. *FY 2011 Base Plans:* - Demonstrate isolation and manipulation of primitive pluripotent stem cells. - Investigate problem statements that can be addressed using quantum information science and technology. - Develop roadmap to algorithm to compute protein folding using quantum computing, as example of speed-up enabled by quantum simulations. - Demonstrate microsystems elements such as inductors and microactuators using high permeability as proof of feasibility to integrate magnetic micro/nanomaterials in wafer-scale processes. - Investigate physical mechanism of cross grain boundary transport in nanocrystalline materials. - Simulate RF performance limits of nanocrystalline channel transistors including current density limits.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Accomplishments/Planned Programs Subtotals	60.894	55.777	70.193	0.000	70.193

	FY 2009	FY 2010
Congressional Add: Advanced Photonic Composites Research *FY 2009 Accomplishments:* - Continued photonic composite development.	1.280	0.000
Congressional Add: Laboratory for Advanced Photonic Composites Research *FY 2010 Plans:* - Initiate laboratory research in photonic composites.	0.000	1.280
Congressional Adds Subtotals	1.280	1.280

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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MS-01: *MATERIALS SCIENCES*	52.150	62.759	78.456	0.000	78.456	90.430	82.750	85.127	90.263	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Nanoscale/Bio-inspired and MetaMaterials	11.894	9.926	10.000	0.000	10.000
(U) 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 2009 Accomplishments:* - Demonstrated automated in-line adaptive optic to correct spatial distortions in high-power, ultra-fast laser wavefront. - Simultaneously demonstrated infrared optical transmission comparable to spinel, and mechanical properties comparable to sapphire, in 75mm discs. - Developed new materials with both optical properties and strength into 75mm flat discs. - Characterized the material properties of 75mm discs through testing in relevant environments. - Demonstrated the ability to provide surface strengthening through compressive materials. - Investigated approaches to design and fabrication of biophotonic structures in the areas of chemical and physical activation for sensor and reflector-based operation. - Developed a polymer-based, structurally biomimetic, electrically switchable photonic shutter.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop new material compositions with optical transmission comparable to spinel and doubled mechanical strength, and thermal shock capabilities over single crystal sapphire. - Initiate fabrication of new materials into hemispherical domes with decreased optical scatter, doubled mechanical strength, and doubled thermal shock capabilities over single crystal sapphire. - Characterize the material properties of hemispherical domes through testing in relevant military environments. - Demonstrate understanding of biophotonic structure/function relationship and design requirements for index/structure actuation. - Demonstrate initial design and fabrication of biophotonic structures. - Initiate development of the capability to compute material properties as a function of the microstructural architectural parameters that govern them, and the extent to which material properties can be modified through the manipulation of these parameters. *FY 2011 Base Plans:* - Demonstrate control of fabrication of biophotonic structures. - Demonstrate physical and/or chemical activation of biophotonic structures. - Demonstrate dynamic control of activation. - Identify expected physical (and/or chemical) sensitivity in terms of reflectance change noted (percent change in reflectance/Volt, percent change in reflectance / molecule adsorbed). - Initiate establishment of experimental fabrication methodologies with level of control needed to produce the materials with architectural features necessary to exhibit predicted properties. - Demonstrate by computation that selected properties may be independently manipulated as a function of these architectural parameters, to a regime currently unachievable. - Demonstrate fabrication methodologies to create the microstructural features with level of control predicted through computation necessary to achieve superior properties.					
Fundamentals of Nanoscale and Emergent Effects and Engineered Devices*	10.676	13.403	21.618	0.000	21.618

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
*Formerly known as Engineered Bio-Molecular Nano-Devices and Systems					

(U) 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, enabling real-time detection as well as analysis of signals and molecules and origin of emergent behavior in correlated electron devices. 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 and emergent behavior.

FY 2009 Accomplishments:
- Used ground-based assets to measure and provide initial characterizations of optical, RF, magnetic, X-ray and gamma ray events associated with rocket triggered lightning.
- Obtained first-ever high-speed photographic image of stepped leader attachment process.
- Developed unprecedented theoretical model of mysterious phenomena known as compact intracloud discharges.
- Demonstrated a multiferroic magnetic sensor (with a field sensitivity of 20 pico-tesla root mean square (rms) per root hertz) that exceeds the sensitivity of any commercially available room temperature sensor.

FY 2010 Plans:
- Demonstrate, in a laboratory environment, low power room temperature single magnetic sensors based on atomic vapor cell magnetometry and on multiferroic composites with sensitivities of 100

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
femtotesla rms per square root hertz (the earth's magnetic field strength varies with location between 30 to 60 microtesla, by comparison). - Demonstrate a 10 x 10 array of magnetic sensors with an overall sensitivity of 1 picotesla rms per square root hertz based on multiferroic composites at a frequency of 1 Hertz. - Demonstrate a 10 x 10 array of magnetic sensors with an overall sensitivity of 1 picotesla rms per square root hertz based on atomic vapor cell magnetometry at a frequency of 1 Hertz. - Develop and validate a 3-D model of critical conditions and processes in clouds and the atmosphere necessary for triggering lightning. - Identify minimum and maximum thresholds associated with lightning phenomena based on geographic location. - Develop a theory of intelligence as a fundamental physical phenomenon that explains the spontaneous creation of structure in the natural world, unifying ideas in thermodynamics, evolution, information, computation and other fields. - Investigate candidate electronic and chemical systems that are capable of self-organizing when placed in a complex environment; use computer simulation to select/refine/improve the candidate systems for further development. - Develop initial analytical tools to measure physical intelligence, and show how these tools relate the activities of a physically intelligent entity to the environment in which it exists. *FY 2011 Base Plans:* - Build and equip facilities capable of launching rockets every thirty seconds in order to trigger lightning and measure associated phenomena. - Correlate terrestrial lightning events with ionospheric phenomena. - Develop a lightning safety model based on new multidimensional data collected during FY 2009-2010. - Create an initial version of a unified theory of physical intelligence and show how it is consistent with the established theories on which it was constructed.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Evaluate the initial theories ability to describe the candidate electronic and chemical systems under development. - Using a combination of simulation and real system hardware, make a limited demonstration of a physical intelligent electronic or chemical system imbedded in an environment of limited complexity. - Refine analytical tools to measure intelligence and demonstrate them on complex, real world systems and their associated data (e.g., biological networks, internet traffic). - Develop more complex demonstrations and extend the theoretical and analytical tools to more complex systems. - Demonstrate novel chemistries and processing techniques that allow for multi-scale (atomic to macro) control in order to synthesize complex material networks which emulate biological systems by self-modulating their properties (structural, visual, acoustic, etc.) in response to external stimulation.					
Atomic Scale Materials and Devices (U) 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. Research on the basic physics and scaling of ionospheric processes utilizing the High Frequency Active Auroral Research Program (HAARP) transmitter will also be explored. New materials and prototype devices will be developed to demonstrate a new class of optoelectronics that operate with ultra-low energy dissipation (~100 atom-Jules (aJ)/operation). *FY 2009 Accomplishments:* - Constructed rotationally sensitive chip-based atom interferometer with sensitivity greater than one radian per earth rotation rate.	13.980	14.150	21.888	0.000	21.888

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Emulated two-dimensional (2-D) Bose-Hubbard Model phase diagram in less than twelve hours that confirmed theoretical calculations. - Installed flat-top beam profile system in experimental chamber; verified production of homogeneous optical lattice potential. - Developed theoretical techniques to extract relevant model-independent thermodynamic quantities from ensemble absorption images. - Demonstrated approximately 100 nm positioning accuracy of quantum dots. - Demonstrated important scalability criterion of microfluidic approach to controlled placement of quantum dots: sequentially built up 3x3 and 5x5 matrices of quantum dots by controlled placement and subsequent immobilization. - Demonstrated non-local modulation of bi-photon wavefunction and demonstrated single photon non-linear switch. *FY 2010 Plans:* - Develop cooling and precision thermometry techniques for fermionic atoms in optical lattice. - Develop quantum gas microscope with sufficient resolution to image individual atomic sites in 2-D optical lattice; verify by imaging atomic gas trapped in lattice. - Emulate XXZ quantum spin model using ion crystal array in less than twelve hours that confirms theoretical calculations. - Develop the materials fabrication techniques for switchable/storable, interfacial metal-insulator transitions to enable extremely low-power transistors for memory and logic. - Develop initial circuit architectures (e.g., logic gates with memory) employing these new transistors for use in new computer architectures. - Demonstrate initial Zeno-based switch using slot waveguides coated or filled with organic nonlinear absorptive materials. - Create a photonic crystal zeno mirror and waveguide with cavity Q > 1000, and loss < 0.1 dB. - Generate and focus X-rays with specific states of orbital angular momentum.					

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** MS-01: *MATERIALS SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiate a series of experimental campaigns to study ionospheric and trans-ionospheric phenomena, including: optimization of high frequency to very low frequency conversion efficiency, wave-particle interaction, generation and propagation of ultra low frequencies, very low frequencies and artificial ducts, triggering and characterization of specific ionospheric instabilities. *FY 2011 Base Plans:* - Demonstrate functional transistors using interfacial metal-insulator transitions and understand their potential for large-scale integrated circuits. - Demonstrate the validity of the initial oxide transistor circuit architectures using computer simulations and/or semiconductor surrogates to approximate the function of these transistors. - Develop a simulator to test the new computer architecture and create tools for configuring and programming machines using the new architecture. - Demonstrate production of antiferromagnetically ordered states in 2-D and 3-D optical lattices. - Study and characterize supersolid behavior in spinor bose condensates. - Produce phase diagram of frustrated 2-D antiferromagnet in less than twelve hours. - Produce phase diagram of 2-D Fermi-Hubbard model at near half-filling; determine presence or absence of superconducting phase. - Demonstrate all-optical switch (or equivalent device) based on optically-induced absorption. - Demonstrate total energy dissipation for an optical switch (or equivalent device) of less than 1 femtojoules per operation, and signal loss of less than 0.1 dB, excluding waveguide losses before and after device. - Demonstrate hyperpolarization of biologically relevant liquids, using photons with orbital angular momentum and measure the hydrogen and carbon-13 polarization. - Obtain hydrogen and carbon-13 spectra from biologically relevant liquid sample using quantum orbital resonance spectroscopy. - Develop prediction of behavior and theoretical models that explore the consequences of controlled power injection, including triggering and amplification phenomena, based on optimal conditions quantitatively determined via measurements gathered in FY 2010.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** MS-01: *MATERIALS SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Characterize ionospheric current drive (ICD), artificially stimulated emissions in the ionosphere, and ionospheric turbulence and associated scintillations.					
Basic Photon Science (U) This thrust examines 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. *FY 2011 Base Plans:* - Investigate the theoretical and practical limits to the information content of a single photon via rigorous application of information theory. - Demonstrate utility of information theoretic approach via improved low-light level imaging and/or high data rate communications. - Develop the basic science required for the exploitation of optical orbital angular momentum in both the classical and quantum realms. - Demonstrate the benefit of orbital angular momentum for communications applications via multi-level signaling and/or turbulence mitigation.	0.000	0.000	8.000	0.000	8.000
Enabling Quantum Technologies* *Previously part of Atomic Scale Materials and Devices (U) This thrust emphasizes a quantum focus on technology capabilities with the potential to revolutionize the approach to various military capabilities. It includes 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	2.000	4.000	10.150	0.000	10.150

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** MS-01: *MATERIALS SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
novel capabilities in the quantum regime, such as GPS-independent navigation via atom interferometry as well as the potential to generate significant heat from deuterated palladium.					

novel capabilities in the quantum regime, such as GPS-independent navigation via atom interferometry as well as the potential to generate significant heat from deuterated palladium.

FY 2009 Accomplishments:
- Established parameters necessary to achieve high levels of deuterium loading with a minimum of electrochemical power.
- Initiated development of the capability to reproducibly generate significant increases in excess heat using electrochemical and gas pressure loaded, highly deuterated palladium.

FY 2010 Plans:
- Quantify the effects of impurities and microstructure in palladium substrate material on the capability to generate excess heat.
- Quantify the required dynamic loading and relaxation conditions and optimize the palladium substrate composition and microstructure required to achieve high levels of deuterium loading and tolerate the high stresses associated with these conditions.
- Investigate use of ultra-cold atoms to probe nuclear spins in complex or heterogeneous materials.
- Develop novel approaches to packaging of superconducting photodetectors enabling plug-and-play coupled quantum efficiencies greater than 50 percent.
- Develop cryogenic readout electronics suitable for packaging in superconducting photodetector arrays.

FY 2011 Base Plans:
- Quantify material parameters that control degree of increase in excess heat generation and life expectancy of power cells.
- Design physics package for optical clock including lasers, optomechanics, associated electronics, and environmental isolation and control subsystems.
- Devise optical fiber-based time and frequency transport protocols and utilize these to design interface to optical clock.

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** MS-01: *MATERIALS SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiate development of unpackaged devices capable of resolving the number of incoming photons at wavelengths compatible with optical fiber. - Initiate development of unpackaged devices capable of generating single photons with high probability at wavelengths compatible with single mode optical fiber (1310 and 1550 nm).					
Surface Enhanced Raman Scattering (SERS) - Science and Technology Fundamentals (U) The Surface Enhanced Raman Scattering (SERS) - Science and Technology program focuses 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 biochemical sensing applications due to: 1) their potential large spectral enhancement factors, 2) the nature of spectral fingerprints that can be expected to yield low false alarm rates, and 3) the capability for detecting targeted molecules at useful stand-off ranges. This program seeks 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 2009 Accomplishments:* - Developed methods to engineer nanoparticles with one nanometer feature sizes (separation) on a macroscale. *FY 2010 Plans:* - Begin assembly or fabrication of one inch SERS active substrates capable of 10^9 enhancements.	8.000	5.000	0.000	0.000	0.000
Dynamics-Enabled Frequency Sources (DEFYS) (U) The Dynamics-Enabled Frequency Sources (DEFYS) program will build on recent advances in very small mechanical systems, nonlinear dynamics, and noise management to revolutionize performance of reference oscillators. Since oscillators are a building block of modern electronics any uncertainty in the frequency they produce will cascade into performance limitations of the larger system. This	0.000	3.300	6.800	0.000	6.800

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** MS-01: *MATERIALS SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
uncertainty often takes the form of phase noise intrinsic to the oscillator or from deleterious external sources and limits performance of a wide range of both military and civilian systems including: radars, communications, sensors, and geo-positioning devices. DEFYS will develop nanoscale mechanical frequency sources that use novel mechanisms in the dynamics to provide a new level of performance in environments of high accelerations or vibrations and temperature variations. Sources developed in this program will provide an unprecedented performance density and will be flexible enough to be integrated into a wide range of applications. *FY 2010 Plans:* - Use nonlinearity-induced mechanisms to reduce phase noise. - Demonstrate acceleration/vibration robustness. - Maintain performance over a large temperature range. *FY 2011 Base Plans:* - Incorporate noise shaping to further reduce phase noise. - Improve acceleration and vibration tolerance. - Improve temperature stability. - Reduce device size.					
Accomplishments/Planned Programs Subtotals	46.550	49.779	78.456	0.000	78.456

	FY 2009	FY 2010
Congressional Add: Comparative Genomics for National Security Goals/Infectious Disease Research *FY 2009 Accomplishments:* - Promoted community interaction and created user groups to test software program and improve system.	2.000	1.200

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** MS-01: *MATERIALS SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
- Identified parameters needed for research areas of transition partners. *FY 2010 Plans:* - Continue to promote community interaction and creation of user groups to test software program and improve system. - Continue to identify parameters needed for research areas of transition partners.		
Congressional Add: Institute for Collaborative Sciences Research *FY 2009 Accomplishments:* - Investigated a collaborative sciences research effort. *FY 2010 Plans:* - Continue investigation of collaborative sciences research.	1.200	2.080
Congressional Add: Advanced Materials Research Institute *FY 2009 Accomplishments:* - Investigated nanoscale engineering of multiferroic materials, and completed design of voltage controlled ferromagnetic material for micro- and nano-scale devices. *FY 2010 Plans:* - Continue investigation of nanoscale engineering of multiferroic materials, and test design of voltage controlled ferromagnetic material for micro- and nano-scale devices.	2.400	0.800
Congressional Add: Hydrogen Fuel Cell Research *FY 2010 Plans:* - Initiate innovative research advances into hydrogen fuel cell technology.	0.000	4.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** MS-01: *MATERIALS SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Solid Oxide Fuel Technology *FY 2010 Plans:* - Investigate innovative advances into solid oxide fuel technology.	0.000	1.000
Congressional Add: Security Protection using Ballistic CORE Technology *FY 2010 Plans:* - Investigate the use of ballistic CORE technology for security protection.	0.000	3.900
Congressional Adds Subtotals	5.600	12.980

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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency			**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** TRS-01: *TRANSFORMATIVE SCIENCES*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TRS-01: *TRANSFORMATIVE SCIENCES*	0.000	0.000	52.500	0.000	52.500	10.000	10.000	10.000	10.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This 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. The project has three key research interest areas: 1) Large-scale custom biological and non-biological manufacturing; 2) Harnessing the power of large-scale, human-centered networks to improve situational awareness; and 3) Adaptable and agile computer networks. Promising research will advance to both technology development and system-level projects.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Transformative Sciences (U) The Transformative Sciences project supports research into converging technological forces and transformational trends in the areas of computing and the computing-reliant subareas of social sciences, life sciences, manufacturing, and commerce. This research has the potential to position the DoD to anticipate the effects of potential discontinuities and gain the ability to adapt quickly and effectively whenever challenging disruptions occur. The research will identify and exploit emerging trends that have the potential to disrupt military operations. Examples of key emerging trends to be investigated include the potential military impact of large-scale custom manufacturing, including the emerging ability to seamlessly convert bits into manufactured objects; “crowd-sourcing”—large-scale, human-centered networks consisting of potentially thousands or millions of people working in collaboration with large-scale computing power, cloud computing, mobile communication devices, and large-scale statistical data analysis toward the solution of a unified goal; and “cyber-agility”—research into a “clean slate” approach to secure, adaptive and agile computer networks.	0.000	0.000	10.000	0.000	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** TRS-01: *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Develop revolutionary 3D printing capabilities to facilitate custom manufacturing on a large scale. - Develop engineered biological systems to create self-replicating materials for radical manufacturing methods. - Develop and apply means of using social networking to dramatically improve military situational awareness, not only of the locations of people and installations, but also social maps, key experiences, and leverage points. - Conduct research into statistical and quasi-experimental analyses of existing data sets to derive answers to key tactical military questions. - Develop adaptable and agile wide-area networks. - Develop means of harnessing large numbers of researchers through "grand Artificial Intelligence (AI) challenges" to assess progress of intelligent systems technologies. - Develop applicable means of harnessing large numbers of networked people to collaboratively solve key problems in Intelligence, Surveillance and Reconnaissance (ISR), image processing, and other applications.					
Deep ISR Processing by Crowds (U) The Deep ISR Processing by Crowds Program goes beyond the concept of putting the human in the loop, and instead looks to harnessing the unique cognitive and creative abilities of large numbers of people to enhance dramatically the knowledge derived from ISR systems. This approach is unconventional in that it involves the massed exploitation of ISR products in concert with other sources of data based on distributed crowd sourcing across human/machine systems. Novel frameworks will be developed to capture the experience base of users and systems to allow optimum problem partitioning, quantitative confidence assessment, and validation in environments that may be partially compromised by adversaries.	0.000	0.000	13.000	0.000	13.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** TRS-01: *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Establishment of exploitation framework including quantitative confidence assessment. - Perform large-scale experimentation and demonstration on sample data sets to quantify performance enhancement.					
Production of Knowledge Bases to Bridge Cultural Divides (U) The Production of Knowledge Bases to Bridge Cultural Divides program will develop 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 application in tactical contexts to aid analysts and operators in connecting the dots amid complex, conflicting, and incomplete data sets. In particular, this program will focus on tool sets to enable actionable exploitation in a timely manner. *FY 2011 Base Plans:* - Development of mathematical and algorithmic modeling and analysis tools. - Establishment of baseline performance and demonstration of enhanced principal component analysis using the tools. - Demonstration of automated and semi-automated processes for exploitation of data collected via experimental analyst assistant.	0.000	0.000	9.500	0.000	9.500
Synthetic Biology (U) The Synthetic Biology program will develop and implement a revolutionary approach to the manufacture of bio-based materials that directly support a broad range of military capabilities, such as sensing of chemical/biological agents, production of bio-based fuels and chemicals, remediation of pollutants, and protection of the food supply chain. Synthetic Biology is based on a revolutionary framework for the algorithmic engineering of biological processes, enabling truly hierarchical biological systems with unbounded complexity. Research thrusts include automated process discovery, tool-	0.000	0.000	20.000	0.000	20.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** TRS-01: *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
chain development, novel approaches to process measurement and validation, and development of application demonstrations. *FY 2011 Base Plans:* - Design biological host organism and complete laboratory demonstration. - Design tool chain frame work and develop workable building blocks for functional outcomes.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	52.500	0.000	52.500

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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Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	236.531	272.191	281.262	0.000	281.262	279.383	239.110	240.443	246.760	Continuing	Continuing
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	93.447	91.757	99.991	0.000	99.991	113.352	53.294	45.092	45.704	Continuing	Continuing
IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*	67.840	113.647	128.930	0.000	128.930	120.976	150.487	159.062	164.808	Continuing	Continuing
IT-04: *LANGUAGE TRANSLATION*	75.244	66.787	52.341	0.000	52.341	45.055	35.329	36.289	36.248	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Information and Communications Technology program element is budgeted in the applied research budget activity because it is directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The High Productivity, High-Performance Responsive Architectures project is developing high-productivity, high-performance computing hardware and the associated software technology base required to support future critical national security needs for computationally-intensive and data-intensive applications. These technologies will lead to new multi-generation product lines of commercially viable, sustainable computing systems for a broad spectrum of scientific and engineering applications; it will include both supercomputer and embedded computing systems.

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

(U) The Language Translation project will develop and test powerful new Human Language Technology that will provide critical capabilities for a wide range of national security needs. This technology will enable systems to a) automatically translate and exploit large volumes of speech and text in multiple languages obtained through

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*

a variety of means; b) to have two-way (foreign-language-to-English and English-to-foreign-language) translation; c) enable automated transcription and translation of foreign speech and text along with content summarization; and d) enable exploitation of captured, foreign language hard-copy documents.

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	250.626	282.749	0.000	0.000	0.000
Current President's Budget	236.531	272.191	281.262	0.000	281.262
Total Adjustments	-14.095	-10.558	281.262	0.000	281.262
• Congressional General Reductions		-1.140			
• Congressional Directed Reductions		-26.818			
• Congressional Rescissions	-3.854	0.000			
• Congressional Adds		2.400			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-3.200	0.000			
• SBIR/STTR Transfer	-7.041	0.000			
• Congressional Restoration for New Starts	0.000	15.000	0.000	0.000	0.000
• TotalOtherAdjustments	0.000	0.000	281.262	0.000	281.262

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2009**	**FY 2010**
Project: IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*		
Congressional Add: *High Speed Optical Interconnects for Next Generation Supercomputing*	0.000	1.200
Congressional Add Subtotals for Project: IT-02	0.000	1.200
Project: IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*		
Congressional Add: *Document Analysis and Exploitation*	1.600	0.000
Congressional Add: *Intelligent Remote Sensing for Urban Warfare*	2.400	1.200
Congressional Add Subtotals for Project: IT-03	4.000	1.200
Congressional Add Totals for all Projects	4.000	2.400

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*

Change Summary Explanation

FY 2009

Decrease reflects transfer of the "National Repository of Digital Forensic Intelligence/Center for Telecommunications and Network Security" congressional add to RDT&E, Air Force account, the Section 8042 rescission of the FY 2010 Appropriation Act, SBIR/STTR transfer and internal below threshold reprogramming.

FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts offset by congressional adds (as identified above) and FY 2010 Congressional Restoration for New Starts.

FY 2011

Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**PROJECT** IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	93.447	91.757	99.991	0.000	99.991	113.352	53.294	45.092	45.704	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The High Productivity, High-Performance Responsive Architectures project is developing high-productivity, high-performance computer hardware and the associated software technology base required to support future critical national security needs for computationally-intensive and data-intensive applications. These technologies will lead to new multi-generation product lines of commercially viable, sustainable computing systems for a broad spectrum of scientific and engineering applications; it will include both supercomputer and embedded computing systems. One of the major challenges currently facing the DoD is the prohibitively high cost, time, and expertise required to build large complex software systems. Powerful new approaches and tools are needed to enable the rapid and efficient production of new software, including software that can be easily changed to address new requirements and can adjust dynamically to platform and environmental perturbations. The project will ensure accessibility and usability to a wide range of application developers, not just computational science experts. This project is essential for maintaining the nation's strength in both supercomputer computation for ultra large-scale engineering applications for surveillance and reconnaissance data assimilation and exploitation, and for environmental modeling and prediction.

(U) Even as this project develops the next generation of high-productivity, high-performance computing systems, it is looking further into the future to develop the technological and architectural solutions that are required to develop extreme computing systems. The military will demand increasing diversity, quantities, and complexity of sensor and other types of data, both on the battlefield and in command centers - processed in time to effectively impact warfighting decisions. Computing assets must progress dramatically to meet significantly increasing performance and cyber-security, while significantly decreasing power and size requirements. Extreme computing systems will scale to deliver a thousand times the capabilities of future petascale systems using the same power and size or will scale to deliver terascale-embedded systems at one millionth of the size and power of petascale systems, and will do so with greatly enhanced security capabilities.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
High-Productivity Computing Systems (HPCS)	65.654	51.933	30.568	0.000	30.568

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**PROJECT** IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
U) The ongoing High-Productivity Computing Systems (HPCS) program will enable nuclear stockpile stewardship, weapons design, crypto-analysis, weather prediction, and other large-scale problems that cannot be addressed productively with today's computers. The goal of this multi-agency program is to develop revolutionary, flexible and well-balanced computer architectures that will deliver high performance with significantly improved productivity for a broad spectrum of applications. Additionally, programming such large systems will be made easier so programmers and scientists with minimal computer skills can harness the power of high-performance computers. The HPCS program will create a new generation of economically viable, high-productivity computing systems for the national security and industrial user communities. (U) In November 2006, the HPCS program moved into the third and final phase, with a down-select from three vendors to two. In Phase III of the HPCS program, the two remaining vendors will complete the designs and technical development of very large (petascale) productive supercomputers, with demonstration of prototype systems in 2010-2012. DARPA funding is sufficient to cover the contractual requirements of one of the two selected vendors. NSA and DOE, partners with DARPA in this program, are providing funding to maintain a second vendor in the program. *FY 2009 Accomplishments:* - Released the beta version application development software to HPCS stakeholders for evaluation and software which provided familiarity prior to system release, thus reducing the learning curve upon system availability. - Fabricated and tested several of the Application-Specific Integrated Circuits. - Continued to develop and implement operating system scaling and performance improvements. - Continued developing productivity tools. - Conducted critical design reviews of each HPCS vendor's system.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Began porting applications to a subset of the actual HPCS prototype hardware in preparation for FY 2010 subsystem demo that will provide evidence that the full prototype system will meet its productivity and performance goals. *FY 2010 Plans:* - Deliver final system test plan for government comment and approval. - Deliver productivity assessment report containing results of assessments to date and plans for future assessments. - Begin early subsystem demonstration of alpha or beta software running on preliminary or surrogate hardware to provide confidence that the prototype (especially hardware/software integration) is on track for FY 2011 final demonstration. - Build prototype hardware. - Integrate software onto hardware. *FY 2011 Base Plans:* - Demonstrate that the Phase III Prototype systems meet their performance and productivity commitments. - Deliver final report on Unified Parallel C (UPC) performance improvements in Symmetric Multiprocessing (SMP), Distributed and Hybrid modes that summarizes all work on UPC and demonstrates performance improvements tuned for computing hardware. - Provide the HPCS stakeholders with access to the prototype systems for a six-month evaluation and experimentation period.					
Architecture Aware Compiler Environment (AACE)* *Formerly a part of Software Producibility	10.111	10.404	13.923	0.000	13.923

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Architecture Aware Compiler Environment (AACE) program will develop computationally efficient compilers that incorporate learning and reasoning methods to drive compiler optimizations for a broad spectrum of computing system configurations. AACE compilers will greatly simplify application development by providing the capability to automatically and efficiently generate compiled code that effectively exercises the targeted computer system resources for computer systems that range from a single, multi-core processor system to very large, multi-processor systems. The AACE program will dramatically reduce application development costs and labor; ensure that executable code is optimal, correct, and timely; enable the full capabilities of computing system advances to our warfighters; and provide superior design and performance capabilities across a broad range of military and industrial applications. *FY 2009 Accomplishments:* - Investigated initial concept for characterization tools and self-assembling compiler elements. *FY 2010 Plans:* - Demonstrate initial improved compiler approaches and characterization tools. - Perform compiler Preliminary Design Review (PDR). - Create the initial common development environment and develop supporting technologies. *FY 2011 Base Plans:* - Initiate integrated compiler and characterization environment incorporating compiler tools demonstration. - Create initial compiler environment and prototype.					
Software Producibility (U) A variety of new processor and systems architectures, including multicore and stream processors, large-scale virtualization, and the cloud computing paradigms are becoming the norm for both military	7.312	1.654	1.500	0.000	1.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and civilian computing infrastructure. Unfortunately, these are highly complex technologies that exceed the capabilities of most of our programmers/application developers, and the result is that the cost of software is skyrocketing. The Software Producibility program will address this critical issue by creating technologies that reduce the cost, time, and expertise required to build large complex software systems, while ensuring that security and service guarantees are met. (U) One promising approach is an intelligent software development system that learns specific implementations of a number of high-level designs, and then uses this knowledge to create initial implementations of novel high-level designs. Automating the development of initial implementations, and then expanding this intelligence to automate debugging will save the software developer considerable time and effort. *FY 2009 Accomplishments:* - Developed tool chains to support optimized verification, field update and security adaptation experiments. - Conducted optimized verification, field update and security adaptation experiments. *FY 2010 Plans:* - Conduct load-time field update experiments. - Conduct preliminary design-time security adaptation experiments. - Conduct run-time adaptation and online run-time reconfiguration experiments. - Explore candidate demonstration systems, in addition to those used by the performer that will foster transition to the Services. - Create initial strategies for software frameworks to support multi-core, stream and cloud computing.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Develop the means to analyze and ensure the security and reliability of software created for multicore, stream and cloud computing architectures. - Create the building blocks for an intelligent development environment that offers support for sketching, gestures, and natural language as interaction modalities in a shared software design task.					
META (U) The goal of the META program is to develop novel design flows, tools, processes, and architectures to enable a significant improvement in the ability to design complex defense and aerospace systems. The program will culminate in the development and demonstration of an aircraft, ground, or naval vehicle of substantial complexity with a reduction in design, integration, manufacturing, and verification level of effort and schedule compression by a factor of five over conventional status quo approach. Likely transition partners will be the platform acquisition components of all three Services and the systems engineering community. *FY 2010 Plans:* - Develop a new model-based systems engineering process, novel design, integration, and verification flows, and appropriate supporting metrics. - Develop a modeling meta-language for the representation of models of both software and physical system components. *FY 2011 Base Plans:* - Develop supporting tools necessary to implement the model-based design, integration, and verification flows. - Using the developed tools, apply the new approach to a notional system design problem. - Determine the specific domain or domains from which the rapid development demo platform will be selected.	0.000	14.000	24.000	0.000	24.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Extreme Computing	10.370	12.566	30.000	0.000	30.000

(U) The Extreme Computing program is creating the technology base necessary for computing systems having performance that exceeds one quintillion operations per second in the post-2010 timeframe. The program is developing the specific technologies necessary for revolutionary improvements relative to scalable performance, productivity, physical size, power, programmability, data bandwidth, latency, and optimized data placement/storage. Within the context of DoD systems, mechanisms for self-modification and self-optimization will enable extreme computing systems to recognize and adapt in real-time to changing requirements, faults, malicious attacks, and opportunities to improve performance through learning. This program will develop self-aware trusted computing techniques that will provide autonomous system monitoring.

(U) The Extreme Computing program addresses several problem areas for embedded and supercomputer systems: power, programming and resiliency. Available hardware is increasingly power hungry, difficult to program, and less resilient to faults/errors. The Extreme Computing program is developing new structured architectures, tools, techniques, and an integrated design flow to enable DoD application developers to efficiently and effectively develop high-performance, mission enabling, affordable, application-specific processors. Field programmable gate arrays (FPGAs) and multi-core processors will receive particular emphasis with respect to programming issues.

FY 2009 Accomplishments:
- Performed extreme scale software study establishing framework for essential, significant changes in computing execution models.
- Analyzed existing individual design tools, identified design tool gaps, established potential approaches for a unified design development framework, and evaluated potential structured Application-Specific Integrated Circuit (ASIC) processing architecture concepts.

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Formulate new processor and memory architectures that will lead to extreme computing. - Develop initial concepts for, and evaluate the feasibility of, computational architectures and computing systems that monitor execution at run time, and dynamically optimize performance (e.g., with respect to caching, on-chip packet routing, etc.) on common applications. - Develop architectural approaches for processing time-critical applications having massive input-output requirements. *FY 2011 Base Plans:* - Develop the identified critical processor technologies, system methodologies, and architectures to enable general-purpose computing systems to perform at extreme computing levels. - Explore, develop, evaluate and perform initial simulations of techniques to enable computing systems to self-monitor their state and adapt in real time. - Perform downselects of initial extreme computing designs. - Establish initial structured ASIC architecture approaches, implement architectural test structures, and develop prototype-supporting integrated FPGA tool flow and design development environments. - Evaluate a prototype approach for large scale data storage.					
Accomplishments/Planned Programs Subtotals	93.447	90.557	99.991	0.000	99.991

	FY 2009	FY 2010
Congressional Add: High Speed Optical Interconnects for Next Generation Supercomputing *FY 2010 Plans:* Initiate research into High Speed Optical Interconnects for Next Generation Supercomputing.	0.000	1.200

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**
Congressional Adds Subtotals	0.000	1.200

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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*	67.840	113.647	128.930	0.000	128.930	120.976	150.487	159.062	164.808	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project is developing the technology required to make emerging information system capabilities (such as wireless and mobile code/mobile systems) inherently secure, and to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are attacked. The technologies will also lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites. Technologies developed under this project will be exploited by all the projects within this program element, and those in the Command, Control, and Communications program element (PE 0603760E), the Network-Centric Warfare Technology program element (PE 0603764E), the Sensor Technology program element (PE 0603767E), and other programs that satisfy defense requirements for secure, survivable, and network centric systems.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Next Generation Core Optical Networks (CORONET)	9.715	16.069	12.785	0.000	12.785
(U) The Next Generation Core Optical Networks (CORONET) program will revolutionize the operation, performance, security, and survivability of the United States' critical inter-networking system by leveraging technology developed in DARPA photonics component and secure networking programs. These goals will be accomplished through a transformation in fundamental networking concepts that form the foundation upon which future inter-networking hardware, architecture, protocols and applications will be built. Key technical enablers that will be developed in this thrust include: 1) network management tools that guarantee optimization of high density wavelength-division-multiplexed (WDM) optical channels 2) creation of a new class of protocols that permit the cross-layer communications needed to support quality-of-service requirements of high-priority national defense applications; and 3) demonstration of novel concepts in applications such as distributed and network based command					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and control, intelligence analysis, predictive logistics management, simulation and scenario enhanced decision-making support for real-time combat operations, and assured operation of critical U.S. networking functions when faced with severe physical layer attack. These network-based functions will support the real-time, fast-reaction operations of senior leadership, major commands and field units. (U) A complimentary effort, the Transmission, Switching and Applications for the CORONET program will develop the technology and applications to realize the next-generation dynamic multi-terabit networks that can deliver advanced internet protocol and optical services. This will be accomplished by: 1) greatly increasing network capacity through the use of more efficient fiber-optical transmission techniques; 2) implementing agile, high capacity, all optical switching platforms, and 3) developing the software and hardware interfaces, as well as the migration strategy, to enable new applications that can take full advantage of dynamic multi-terabit core optical networks. *FY 2009 Accomplishments:* Next-Generation Core Optical Networks (CORONET) - Completed the development of protocols and algorithms, and developed the network control and management architecture to provide fast service setup, fast restoration from multiple network failures and guaranteed quality of service for a global core optical network. - Modeled and simulated a dynamically reconfigurable multi-terabit global core optical network. Transmission, Switching and Applications for CORONET - Initiated the development of high-spectral efficiency banded wavelength division multiplexing (WDM) fiber-optic transmission system to enable several-fold increase in fiber capacity while providing a good match in the optical domain to the bit rate of the end user. - Architected a multi-terabit all-optical switch capable of fast switching of wavelengths and wavebands and of grooming wavelengths among wavebands.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: Next-Generation Core Optical Networks (CORONET) - Work with DISA to ensure that CORONET's next phase incorporates the requirements and technology evolution plan of their DISN-Core network. - Initiate the CORONET next phase development of the network control and management software and the associated test plan such that the final product will be suitable for transition and implementation in current and future commercial and DoD core optical networks. Transmission, Switching and Applications for CORONET - Complete the development and test of high-spectral efficiency banded WDM fiber-optic transmission system. - Prototype a multi-terabit all-optical switch capable of fast switching of wavelengths and wavebands and of grooming wavelengths among wavebands. *FY 2011 Base Plans:* Next-Generation Core Optical Networks (CORONET) - Continue the CORONET next phase effort to develop the network control and management software, the CORONET network-emulation testbed and the plans for technical testing and demonstrations, and complete the technology transition plan. - Continue to work with DISA on technical oversight and evaluation of the CORONET software development effort and associated test plan. - Begin developmental testing of the network control and management software on the network-emulation testbed. - Engage Standards Bodies, with the appropriate endorsements of both DISA and the commercial carrier members of the CORONET team, with the goal of amending the existing standards with the developed CORONET technology. - Pursue opportunities for commercial transition as well as future integration into the DISN-Core and other DoD networks.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Transmission, Switching and Applications for CORONET - Integrate the fiber-optic banded transmission system and the multi-terabit all-optical switch and the associated control and management software and test in a proof-of-concept test bed. - Initiate a national-scale multi-terabit network testbed to test and demonstrate hardware, software and applications of next-generation core optical networks.					
Intrinsically Assured Mobile Ad-Hoc Networks (IAMANET) (U) The Intrinsically Assured Mobile Ad-Hoc Network (IAMANET) program continues a series of successful research programs to design a tactical wireless network that is secure and resilient to a broad range of threats which include cyber attacks, electronic warfare and malicious insiders (or captured/compromised radios). Previous programs included the Dynamic Quarantine of Computer-Based Worms (DQW) and Defense Against Cyber Attacks on Mobile Ad-hoc Network Systems (DCAMANET). (U) IAMANET will build upon the successes achieved in both the DQW and the DCMANET programs. IAMANET directly supports the integrity, availability, reliability, confidentiality, and safety of Mobile Ad-hoc Network (MANET) communications and data. In contrast, the dominant Internet paradigm is intrinsically insecure. For example, the Internet does not deny unauthorized traffic by default and therefore violates the principle of least privilege. In addition, there are no provisions for non-repudiation or accountability and therefore adversaries can probe for vulnerabilities with impunity because the likelihood of attributing bad behavior to an adversary is limited. Current protocols are not robust to purposely induced failures and malicious behavior, leaving entire Internet-based systems vulnerable in the case of defensive failure. IAMANET, on the other hand, uses a deny-by-default networking paradigm, allowing only identifiable authorized users to communicate on the network. While the objective transition path for IAMANET technologies is to the Services to support mobile tactical operations, the IAMANET systems are interoperable with fixed networks and may also have potential applicability to the broader DoD network architecture.	7.432	14.543	11.912	0.000	11.912

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Completed the design, development and testing of two approaches for an assurable network infrastructure (architecture, control and management, algorithms and policies). - Completed a red team evaluation of the performance of the assurable network infrastructure using a simulation of a 94 node mobile network. - Hardened DQW system against directed attacks. - Improved DQW detection and response capabilities discovered from testing. - Tested integrated DQW system on operational network. - Tested integrated DQW system against red teams (attack teams) during Combatant Command exercise. - Initiated transition of technology to DoD. *FY 2010 Plans:* - Initiate the design, development and integration of a secondary defensive subsystem (similar to what was developed under DCAMANET and the Dynamic Quarantine of Worms) for handheld devices. - Initiate design and development of trusted hardware components for specific key functions. *FY 2011 Base Plans:* - Complete the design and development of a fully integrated prototype handheld IAMANET system. - Conduct a red team test and assessment of the fully integrated prototype handheld IAMANET system. - Initiate field test and demonstrations of a medium unit set of IAMANET systems (<100 radios) in a representative operational environment.					
Trustworthy Systems (U) The goal of the Trustworthy Systems program is to provide new approaches to network-based monitoring that provide maximum coverage of the network (i.e. from the NIPRNET/Internet gateway down) with performance independent of the network's size and with computational costs that either	9.229	13.090	7.731	0.000	7.731

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
remain constant or decrease as the network's speed or relative size increases. The end deliverable of this program will provide network defense technologies with: (1) a 99% probability of detection (Pd) of malicious traffic per attack launched and, (2) a false alarm rate of not more than one false alarm per day. This technology will provide gateway-and-below network traffic monitoring approaches that scale at rates that are linear (or less) to increases in network size and transmission speeds. Transition partners include the National Security Agency, the Defense Information Systems Agency, and the military Services. *FY 2009 Accomplishments:* - Conducted studies on the statistical and temporal composition of prevailing traffic patterns. - Developed design architecture capable of supporting both symmetrical and asymmetrical traffic generation at speeds up to 1 Gigabite per second (Gbps). - Developed design architectures capable of generating simulated real-world traffic at network layers 2-7. - Developed traffic capturing methods in support of verifying false-positive conditions from scalable network monitoring systems being tested. - Designed a testbed that scales up to 10 Gbps, 40 Gbps, and 100 Gbps. - Designed and built 10 Gbps network monitoring devices. *FY 2010 Plans:* - Build and test a testbed that scales to traffic generation of up to 100 Gbps. - Scale a monitoring system to support line speeds of up to 100 Gbps. - Conduct a study to examine the levels of traffic fluctuation now as well as future trends. - Investigate revolutionary designs and technologies of the confident computing system, to include embedded operating systems and hypervisors. - Test network monitoring hardware at 10 Gbps and 40 Gbps.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Port system code to final hardware platform. - Test network monitoring hardware at 100 Gbps. - Transition to the agency partners listed above.					
Security-Aware Systems (U) The Security-Aware Systems program will develop and advance a variety of potentially promising technologies to enable the military to field secure, survivable, self-monitoring, self-defending network centric systems. This program will develop security aware systems that will avoid brittleness and vulnerability, due to their ability to reason about their own security attributes, capabilities and functions with respect to specific mission needs. These systems will also dynamically adapt to provide desired levels of service while minimizing risk and providing coherent explanations of the relative safety of service level alternatives. These systems will bolster the reliability and security of critical, open source software systems by reducing vulnerabilities and logic errors, and providing state-of-the-art software analysis techniques augmented with cognitive decision-making techniques with the ultimate goal of applying these systems on to the Global Information Grid. Research efforts will also explore provable protection of information within systems that exhibit imperfect security. A new kind of computational framework is needed that enables critical information and program separation properties (e.g., information in one graphical user interface (GUI) window never leaks to another GUI window). Security-Aware Systems will also address the so-called “insider threat” by developing technologies that enable a fundamentally new approach for detecting insider threats that exploits recent advances in cognitive science to accurately model and learn the normal behavior of users. (U) The Application Communities (AC) effort will develop technologies to protect DoD information systems that employ commercial software applications against cyber attack and system failure by developing collaboration-based defenses that detect, respond to, and heal from attacks with little or no human assistance. The effort will leverage advances in information assurance research programs to	9.207	11.225	12.000	0.000	12.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
create a new generation of self-defending software that automatically responds to threats, and provides a comprehensive picture of security properties, displayed at multiple levels of abstraction and formality. This capability will bring intelligent security adaptation to DoD systems, and make security properties and status more apparent to decision makers. AC technology will enable collections of similar systems to collaboratively generate a shared awareness of security vulnerabilities, vulnerability mitigation strategies, and early warnings of attack. AC will revolutionize the security of military information systems and reduce the threat from stealthy intrusion of critical systems and/or denial of service attacks. (U) The Self-Regenerative Systems (SRS) effort will design, develop, demonstrate and validate architectures, tools, and techniques for fielding systems capable of adapting to novel threats, unanticipated workloads and evolving system configurations. SRS technology will employ innovative techniques like biologically-inspired diversity, cognitive immunity and healing, granular and scalable redundancy, and higher-level functions such as reasoning, reflection and learning. SRS technologies will make critical future information systems more robust, survivable and trustworthy. SRS will also develop technologies to mitigate the insider threat. SRS-enabled systems will be able to reconstitute their full functional and performance capabilities after experiencing accidental component failure, software error, or even an intentional cyber-attack. These systems will also show a positive trend in reliability, actually exceeding initial operation capability and approaching a theoretical optimal performance level over long periods while maintaining robustness and trustworthiness attributes. *FY 2009 Accomplishments:* - Developed regimes to assess the protection mechanisms of security products, thereby providing a mechanism to certify protection to quantifiable levels based on a scientific rationale. - Developed additional general strategies to automatically immunize systems against new attacks and preempt insider attacks, enable anomaly detection, combine and correlate information from system layers, and use direct user challenges.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Employ SRS technology with a high value, mission critical, military computing system exemplar to demonstrate the system's ability to successfully complete the mission in the face of cyber attack or accidental fault. - Validate SRS technology by subjecting exemplar system to cyber attack by Red Team. - Begin the process of transition of selected self-regeneration technology to a military computing system of record. - Obtain realistic exemplars of insider threat activities. *FY 2011 Base Plans:* - Mature and evaluate technologies enabling development of a computer network that rapidly identifies, localizes and suppresses attacks and accidental faults automatically, and provides an early warning system that predicts these events. - Continue the process of transition of selected self-regeneration technology to a military computing system of record. - Use machine learning to develop rule-based models of user behavior.					
Cyber Genome* *Formerly Code Characterization. (U) Traditional cyber forensics has focused on tracing network adversaries and manual analysis of computer hosts after obtaining physical possession of the machine. Electronic evidence is fragile and can easily be modified. Additionally, cyber thieves, criminals, dishonest and even honest employees hide, wipe, disguise, cloak, encrypt and destroy evidence from storage media using a variety of freeware, shareware and commercially available utility programs. The program will develop revolutionary methods to autonomously collect, interpret and compare computer software characteristics, while mapping them against a gene-inspired construct. The program will develop	1.750	8.500	13.000	0.000	13.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
break-through cyber forensic techniques to characterize, analyze and identify malicious code. This program will also develop breakthrough abilities in visualization, threat identification analysis and threat mitigation analysis to enable positive identification of malcode sub-structures and functionality. This program will allow for the automatic discovery, identification, and characterization of any future variants of previously unknown malicious code in computing systems. *FY 2009 Accomplishments:* - Investigated revolutionary methods to autonomously extract meta data and other characteristics from multiple computing platforms. - Investigated innovative methods to determine the properties of new software code and how that code compares/contrasts to any other code. *FY 2010 Plans:* - Develop automatic techniques to rapidly and interactively reconstruct meta data to assist in the analysis of potential malicious code. - Prototype an overall system that allows for the introduction of new software code via a non-proprietary method. - Refine technologies, ontology's, and algorithms to enable the characterization of future malicious code variants based on analyzed malcode substructures. - Establish teams and community training / test data sets to evaluate the malicious code detection techniques. *FY 2011 Base Plans:* - Develop a model to determine characteristics/patterns of a user's interaction with machine hardware and software to collect signature data which can identify potential adversary users. - Complete integration of automatic discovery, identification, analysis, and prediction algorithms. - Refine user signature identification model and correlate with physical security methods.					
Trusted, Uncompromised Semiconductor Technology (TrUST)	24.507	39.020	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Trusted, Uncompromised Semiconductor Technology (TrUST) program addresses the fundamental problem of determining whether a microchip manufactured through a process that is inherently “untrusted” (i.e., not under our control) can be “trusted” to perform operations only as specified by the design, and no more. The program will consist of a set of complementary technologies integrated together in order to develop a product that can be transitioned to the DoD. Continuation efforts are funded in the Discover program. *FY 2009 Accomplishments:* - Increased the speed of automated delayering and image processing to compare and detected changes in a fabricated IC device against the design file for a design of 10^6 transistors in 240 hours. - Increased complexity and thoroughness of Integrated Circuit (IC) design verification tools and developed methods to verify the integrity of 3rd Party Intellectual Property (IP) blocks that can work in the presence of unknown cell libraries for Application Specific Integrated Circuits (ASICs) and Field Programmable Gate Arrays (FPGAs) for a design of 10^6 transistors in 240 hours. - Continued to refine and expand tools for FPGA verification and extended the number of FPGA families that they target for a design of 10^6 transistors in 240 hours. - Protected FPGAs from unauthorized substitutions by improving and empirically verifying the software/firmware framework for using Physically Unclonable Functions. *FY 2010 Plans:* - Increase the speed of automated delayering and image processing to compare and detect changes in a fabricated IC device against the design file for a design of 10^7 transistors in 120 hours. - Increase complexity and thoroughness of IC design verification tools and develop methods to verify the integrity of 3rd Party Intellectual Property (IP) blocks that can work in the presence of unknown cell libraries for ASICs and FPGAs for a design of 10^7 transistors in 120 hours. - Continue to refine and expand tools for FPGA verification and extend the number of FPGA families that they target for a design of 10^7 transistors in 120 hours.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Protect FPGAs from unauthorized substitutions, this will improve and empirically verify the software/ firmware framework for using Physically Unclonable Functions. - Integrate a complete TrUSTed IC solution for ASICs and FPGAs that is ready for transition. - Develop advanced IC reverse engineering techniques that can work backwards from hardware samples to derive the functionality of ICs produced with 32 nm fabrication technology. - Identify, develop, and quantify performance of innovative destructive and non-destructive evaluation techniques for 32 nm ICs which can fully evaluate the IC functionality.					
DISCOVER (U) The DISCOVER program will continue and expand the efforts initiated in TrUST, and focus on the more difficult problem of indentifying rogue components or circuitry in unknown designs. The Department of Defense has become increasingly reliant on electronic parts and systems fabricated outside of the United States. In many cases, these parts have also been designed in foreign countries, and there is currently no method available to decipher the full functionality of these circuits that may contain billions of transistors. Even if the part is designed domestically, there is currently no way of verifying that tampering has not occurred during fabrication, especially as processing technology scales to near atomic length scales. Unreliable electronic systems could potentially compromise the warfighter's mission or safety. DISCOVER will advance non-destructive reverse engineering of integrated circuits whose functionality is not known a priori. These tools will be compatible with leading edge 32 nanometer Complementary Metal-Oxide-Semiconductor (CMOS) node size. These tools will ensure that an integrated circuits has full functionality and will provide verification that no malicious changes have been introduced. *FY 2010 Plans:* - Commence definition of functional requirements for algorithms that determine circuit functionality absent knowledge of their underlying logic and design.	0.000	10.000	17.878	0.000	17.878

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete definition of functional requirements for algorithms that determine circuit functionality absent knowledge of their underlying logic and design. - Design tools for non-destructive interrogation of integrated circuit functionality without prior knowledge of the designed functionality.					
Cyber Authentication (U) Current practice for the authentication of military personnel to information systems and facility access uses one or more factors; something you know – passwords, something you have – access cards, and/or something you are – biometrics. Today, biometrics, a method to uniquely authenticate an individual based on one or more physical or behavior traits, relies on being able to access the individuals body (fingerprint, retina scan, face recognition, DNA) and human behavior (voice, typing rhythm) and are preferred means to identify persons. The intent of the Cyber Authentication program is to reduce the authentication burden as well as strengthening the overall network security posture of the Global Information Grid by implementing autonomous 3-factor authentication. The Cyber Authentication program will accomplish this by revolutionary non-intrusive biometric identification tied to human physiology providing autonomous network defense through consistent and non-repudiated authentication. The Cyber Authentication system will securely identify unique individuals when the individual is within proximity of a computing device. A potential transition path of this program is a commercial capability to remotely identify individuals to their commercial systems without needing to interact with today's burdensome biometric systems or remembering logon and passwords combinations. *FY 2011 Base Plans:* - Investigate revolutionary designs and technologies regarding biometric authentication utilizing micro-sensors and remote identification technologies.	0.000	0.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
- Establish an independent validation and verification team to critique performers during the design phase of the program. - Coordinate with first response community.					
Total Software Understanding (TSU) (U) The Total Software Understanding (TSU) program seeks to develop automated tools that provide insight into the internal structure and operation of software. Current software projects are massive, dynamic social efforts involving distributed teams of developers, marketers, and users. As a result, there are multiple segments of the software being written simultaneously by different people with their own unique coding style. This segmentation of software development along with the nonstop submission of bug reports result in a continuous evolution of the system design as the software project is being developed. Over time, the software grows in size, developers phase out, and the fundamental core, structure, and layout becomes convoluted and difficult to understand. The TSU program will resolve this issue by developing software tools that distill intended software behavior and verify the intended behavior against the actual behavior. The TSU program will determine software behavior in an automated manner through low-level code analysis techniques and by examining the software development history and socio-economic impact data available during the time of development. The software tools developed under the TSU program will permit visualizations of software properties and logic flows as well as allow a historical and performance analysis of those properties. TSU will enable software engineers to diagnose software for inefficiencies, logic errors, redundant code, and overall software inconsistencies. The tools developed under the TSU program will permit automated software restructuring for efficiency. The ultimate goal of the TSU program is to build tools that enable software developers to improve the overall quality of current and future software products. The software tools developed in this program will enable the improvement and modernization of legacy and open source software, as well as improve and guide future software engineering practices and techniques. This effort will transition to the Department of Defense (DoD) agencies, Military Services, academic, and commercial sectors.	0.000	0.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Develop models from historical, socio-economic data, and software builds for analysis. - Develop tools to perform historical analysis of software builds/releases over time. - Develop tools to analyze models for intended behavior.					
Confident Computing (C-2) (U) The Confident Computing (C-2) program will radically change the current paradigm of overly complex, unwieldy, and insecure computing platforms. Current commercial off-the-shelf (COTS) systems do not keep pace with the security requirements of the Department of Defense and other government agencies; they are incentivized to add layer upon layer of functionality and backwards compatibility, without significantly improved security. The C-2 program will leverage enhanced processor and memory technologies developed under the Trustworthy Systems program to revolutionize the “minimalization” of a micro-core operating system, designed to quantifiably defeat adversaries’ attempts to compromise the system during computing operations specific to military operations, rather than home use. The resulting technology of the C-2 program will initially be used either as a component or complete system to allow secure command and control communications for deployed forces. Subsequent phases of the program will allow for expanded usability and functionality for in-garrison usage. Mature C-2 technologies will not require add-on security controls (e.g., Anti-Virus, Firewall, etc.) nor time-consuming maintenance from system administrators, thus improving performance and decreasing costs in order to facilitate transition to an operational performer. *FY 2011 Base Plans:* - Investigate revolutionary designs and technologies of the C-2 system, including embedded operating systems and hypervisors. - Develop technology via approved software development life cycle approach. - Establish an independent validation and verification team to critique the performers during the design phase of the technologies.	0.000	0.000	5.349	0.000	5.349

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Securing the Hosts	0.000	0.000	9.275	0.000	9.275
(U) The Securing the Hosts program will meet the steadily increasing DoD demands for a new computing infrastructure with a much higher level of security. Securing the Hosts will create new, safer, computer languages and compilers; formal automated proof tools and development environment for security throughout the execution model; and techniques for design and pre-run-time validation of executables. The Securing the Hosts program will take a clean slate approach to the execution model; executables will be crypto-bound to the lower levels of the execution model, subject to proofs checks, and constructed with security-aware languages. Technical approaches will include, but are not limited to co-development of hardware and low level system software, with cryptographic microcontrollers to permit cryptographic handshaking at all system layers; lower levels of the execution model establish a root of trust from the hardware out through the hypervisor and other secure low-level software, cryptographically bound to the upper levels of the execution model; novel hardware architectures for data-provenance tracking, access rights enforcement, information flow tracking and tagging, cryptography, logic, memory, and data access to support secure execution; and provably secure hypervisor. *FY 2011 Base Plans:* - Develop concepts for a clean-slate re-design of the upper portion of the execution model, including the programming model, compiler, libraries, run time, and operating system. - Develop concepts for a clean-slate re-design of the upper portion of the execution model, including virtual machines, the micro operating system, hardware abstraction layer, hypervisor, CPU, and crypto microcontroller. - Create concepts for co-design of the execution model, hardware and verification technologies to ease proofs and dynamic enforcement of security properties. - Create initial implementations for new, provably-secure elements of the execution model. - Develop concepts and initial implementations for providing arbitrary computation on encrypted data.					
Securing the Network	0.000	0.000	9.000	0.000	9.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Securing the Network program will meet the steadily increasing DoD demands for a new networking infrastructure with a much higher level of security. Clean slate architectures for Internet protocols are needed that reflect security and trust explicitly in their design, starting with network and transport functions, to derive far greater roots of trust. Protocols that reflect more compute intensive approaches to control are enabled by the drastic reduction of computing cost, compared to design assumptions decades ago. Specific approaches will include, but are not limited to, cryptographic handshake at all network layers above physical and data link functions; network management software that exhibits strong roots of trust, running in trusted substrates; routers that permit significant computing power to be applied at intermediate points along the data pathways and provide virtualization features enabling multiple protocols to be deployed; and information movement based on object-by-object encryption, with accountability enforced in network appliances at all network levels. *FY 2011 Base Plans:* - Develop concepts for a clean-slate re-design of Internet protocols that reflect security and trust explicitly in their design, starting with layer 3 and 4 protocols (network and transport functions). - Develop concepts for an accountable cyberinfrastructure in which it is possible to trace flows to establish the provenance, and by implication the trustworthiness, of network data and information. - Create initial designs for Internet protocols that reflect security and trust explicitly in their design, starting with layer 3 and 4 protocols (network and transport functions). - Develop initial implementations for highly available, censorship-resistant network infrastructure.					
Rapid Planning (RP) (U) The Rapid Planning (RP) effort will develop rapid planning and replanning tools based on a mathematical foundation. The program will develop tools and techniques for rapid generation and adaptation of robust plans in the presence of uncertainty, imprecision, incomplete, and contradictory data and assumptions. RP will also provide a capability for monitoring plans, providing continuous replanning capability, and plain text explanations for recommended plans. RP will invest in	0.000	0.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
mathematical methods to improve optimization including new branch and bound, mixed integer programming, and sub-modularity methods; techniques for accelerated simulation where accuracy can be traded for speed; design of experiments through manifold learning and identification techniques that build upon previous DARPA programs; and develop a process that is aware of interdependencies in plans and aids planners in resolving these interdependencies. *FY 2011 Base Plans:* - Create overarching system architecture for rapid replanning incorporating environmental and tactical uncertainty. - Design automated identification of the controlling and nuisance parameters to control accuracy.					
Cyber Immune (U) Cyber security is one of the top challenges facing the DoD and the nation. Despite many years of research in this area, the security of the Internet and our computing systems continues to be insufficient to support the degree of dependence that is increasingly vested in this infrastructure by the military and industry. At the same time, in several other areas such as robotics, DARPA has made significant new breakthroughs by using the mechanisms of biological systems as inspiration for radical re-thinking of basic hardware and system designs. This project seeks to accomplish the same in the cyber-security area. It will investigate and develop new approaches to cyber-security inspired by biological systems, in order to gain major improvements. Higher levels of system security will come from new biologically inspired models that will replace the failed model of perimeter defense that currently dominates today's information systems. This project will develop cyber-resilient systems that assume security cannot be absolute, yet a system that can still defend itself in order to maintain its (possibly degraded) capabilities, and possibly even heal itself. *FY 2011 Base Plans:* - Develop new models of software that enable systems to detect the presence of cyber-attack agents.	0.000	0.000	15.000	0.000	15.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Create new techniques for software systems to garner its resources for cyber-defense while still maintaining some of its operating capabilities. - Develop initial concepts for methods of warding off attacks and, when possible, healing the system.					
Control-Based Mobile Ad-Hoc Networks (CBMANET) (U) The Control-Based Mobile Ad-Hoc Networks (CBMANET) program developed an adaptive networking capability that dramatically improved performance and reduced life-threatening communication failures in complex communication networks. The program focused on tactical mobile ad-hoc networks (MANETs) that were inadequately supported with commercial technology. To address this problem, the CBMANET program exploited recent optimization-theoretic breakthroughs, recent information-theoretic breakthroughs, and comprehensive cross-layer design to develop a network stack from first principles with specific attention to support for DoD applications such as multicast voice video, chat, file transfer, and situation awareness. *FY 2009 Accomplishments:* - Completed development and integration into military radio systems. - Executed final experiments and military demonstrations. - Transitioned activities to the Services.	2.000	0.000	0.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	63.840	112.447	128.930	0.000	128.930

	FY 2009	FY 2010
Congressional Add: Document Analysis and Exploitation *FY 2009 Accomplishments:* - Conducted research in document analysis and exploitation.	1.600	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Intelligent Remote Sensing for Urban Warfare *FY 2009 Accomplishments:* - Conducted research in remote sensing for urban warfare. *FY 2010 Plans:* - Continue to conduct research in remote sensing for urban warfare operations.	2.400	1.200
Congressional Adds Subtotals	4.000	1.200

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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
IT-04: *LANGUAGE TRANSLATION*	75.244	66.787	52.341	0.000	52.341	45.055	35.329	36.289	36.248	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project is developing powerful new technologies for processing foreign languages that will provide critical capabilities for a wide range of military and national security needs, both tactical and strategic. The technologies and systems developed in this project will enable our military to automatically translate and exploit large volumes of speech and text in multiple languages obtained through a variety of means.

(U) Current U.S. military operations involve close contact with a wide range of cultures and peoples. The warfighter on the ground needs hand-held, speech-to-speech translation systems that enable communication with the local population during tactical missions. Thus, tactical applications imply the need for two-way (foreign-language-to-English and English-to-foreign-language) translation.

(U) Because foreign-language news broadcasts, web-posted content, and captured foreign-language hard-copy documents can provide insights regarding local and regional events, attitudes and activities, language translation systems also contribute to the development of good strategic intelligence. Such applications require one-way (foreign-language-to-English) translation. Exploitation of the resulting translated content requires the capability to automatically collate, filter, synthesize, summarize, and present relevant information in timely and relevant forms.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Spoken Language Communication and Translation System for Tactical Use (TRANSTAC)	11.533	7.738	2.500	0.000	2.500
(U) The Spoken Language Communication and Translation System for Tactical Use (TRANSTAC) program is developing technologies that enable robust, spontaneous, two-way tactical speech communications between our warfighters and native speakers. The program addresses the issues surrounding the rapid deployment of new languages, especially low-resource languages and dialects. TRANSTAC is building upon existing speech translation platforms to create a rapidly deployable					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
language tool that will meet the military's language translation needs. TRANSTAC is currently focusing on key languages of the Middle East region. *FY 2009 Accomplishments:* - Updated/enhanced the experimental systems in the field. - Continued mission needs analysis and aggressive language data collection. - Developed an initial Dari prototype that will undergo further testing. *FY 2010 Plans:* - Test and refine the Dari prototype. - Develop context management translation techniques. - Demonstrate a hands-free, eyes-free, two-way translator prototype. - Extend translation techniques to develop translation systems emphasizing other key languages (e.g., Pashto). *FY 2011 Base Plans:* - Develop simultaneous multi-lingual translation techniques. - Demonstrate a multilingual translation prototype. - Test translation systems emphasizing other key languages.					
Global Autonomous Language Exploitation (GALE) (U) The Global Autonomous Language Exploitation (GALE) program will provide, in an integrated product, automated transcription and translation of foreign speech and text along with content summarization. When applied to foreign language broadcast media and web-posted content, GALE systems will enhance open-source intelligence and local/regional situational awareness and eliminate the need for translation and subject matter experts. Continuing work under GALE will produce a fully mature integrated architecture and dramatically improve transcription and translation accuracy by exploiting context and other clues. GALE will address unstructured speech such as talk show	46.396	37.353	22.945	0.000	22.945

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
conversations and chat room communications, developing timely, succinct reports and alerts for commanders and warfighters. *FY 2009 Accomplishments:* - Incorporated syntactic analysis of the source languages (Arabic and Chinese) and developed more accurate word alignment between source and target languages. - Performed design and feasibility experiments for extraction-empowered machine translation, where the system extracts the meaningful phrases (e.g., names and descriptions) from foreign language text for highly accurate translation into English. - Analyzed English sentences (original or translated) in terms of the editorial 5W's (Who, What, Where, When and Why) and designed methods for evaluating the results. - Continued transitioning preliminary technologies developed by the GALE program into high-impact military systems and intelligence operations centers. *FY 2010 Plans:* - Develop methods for porting technology into new languages. - Complete the architecture for a summarization system that incorporates adaptive filtering, focused summarization, information extraction, contradiction detection, and user modeling. - Continue incorporating predicate-argument analysis to enhance machine translation and summarization. - Develop methods for using extraction-empowered machine translation, where the system extracts the meaningful phrases (e.g., names and descriptions) from foreign language text for highly accurate translation into English. - Continue to transition technologies developed by the GALE program into high-impact military systems and intelligence operations centers. - Exercise language independent paradigm for new languages essential for military use - Dari, Pashto and Urdu.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Continue improvement of transcription and translation algorithms, use of shallow semantics to achieve high accuracy translation and distillation, and evaluation of translation and distillation technologies. - Achieve the ultimate GALE targets of ninety-five percent translation accuracy and distillation that exceeds human performance. - Continue to transition technologies developed by the GALE program into high-impact military systems and intelligence operations centers. - Continue development of Dari, Pashto and Urdu in addition to GALE languages of Arabic and Chinese translation.					
Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) (U) The Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) program will develop and integrate technology to enable exploitation of captured, foreign language, hard-copy documents. This technology is crucial to the warfighter, as hard-copy documents including notebooks, letters, ledgers, annotated maps, newspapers, newsletters, leaflets, pictures of graffiti, and document images (e.g., PDF files, JPEG files, scanned TIFF images, etc.) resident on magnetic and optical media captured in the field may contain important, but perishable information. Unfortunately, due to limited human resources and the immature state of applicable technology, the Services lack the ability to exploit in a timely fashion ideographic and script documents that are either machine printed or handwritten in Arabic. The MADCAT program will address this need by producing devices that will convert such captured documents to readable English in the field. MADCAT will substantially improve the applicable technologies, in particular document analysis and optical character recognition/optical handwriting recognition (OCR/OHR). MADCAT will then tightly integrate these improved technologies with translation technology and create demonstration prototypes for field trials.	12.639	13.500	15.375	0.000	15.375

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**PROJECT** IT-04: *LANGUAGE TRANSLATION*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Continued improving methods for document segmentation (e.g., title, address box, columns, lists, embedded picture/diagram/caption, annotation, signature block, etc.). - Developed improved algorithms for document type identification (e.g., letter, ledger, annotated map, newspaper, etc.) for discrimination and separation of handwriting from printed regions; and for improved OCR/OHR. - Created better means of interpreting different regions within a document such as extracting information from an address field or the axes of a table. - Developed algorithms to predict the syntactic structure and propositional content of text, and for recognizing and transcribing hand-written text. - Integrated these improvements with the translation component of GALE to yield tightly integrated technology prototypes that convert captured documents into readable and searchable English. - Enabled efficient metadata-based search and retrieval. *FY 2010 Plans:* - Develop optimized algorithms for interpreting different regions within a document, such as extracting information from an address field or the axes of a table; for predicting the syntactic structure and propositional content of text; and for removing noise from contaminated and degraded documents. - Integrate these improvements with the translation and summarization components of GALE to yield tightly integrated technology prototypes that convert captured documents into readable and searchable English. - Transition tightly integrated technology prototypes to high-impact military systems and intelligence operations centers. - Extend language independent technology to languages also using Arabic script - Dari, Pashto and Urdu.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete the development and optimization of algorithms for interpreting different regions within a document, such as extracting information from an address field or the axes of a table; for predicting the syntactic structure and propositional content of text; and for removing noise from contaminated and degraded documents. - Complete the integration of these improvements with the translation and summarization components of GALE. - Transition tightly integrated technology prototypes that convert captured documents into readable and searchable English to high-impact military systems and intelligence operations centers. - Continue development of language independent technology extension to Dari, Pashto and Urdu.					
Robust Automatic Translation of Speech (RATS) (U) The Robust Automatic Translation of Speech (RATS) program will address noisy and hostile conditions where speech is degraded by distortion, reverberation, and/or competing conversations. Research into the issue of robustness to enhance the capabilities of speech processing will enable soldiers to hear or read clear English versions of what is being said in their vicinity, despite a noisy or echoic environment. In extremely noisy conditions, the technology developed through RATS will be able to isolate and deliver pertinent information to the warfighter by detecting periods of speech activity and discarding silent portions. RATS technology will also be able to detect the language spoken, identify the speaker, and search for key words in dialogue. RATS technology will build upon advances in GALE translation technology. *FY 2009 Accomplishments:* - Evaluated the relative benefits (performance versus computational requirements) of noise suppression and speech exploitation based on a single microphone versus using a dual-microphone.	4.676	8.196	11.521	0.000	11.521

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Assessed the current state of the art in speech processing for noisy environments, including echo suppression, speech activity detection, language identification, speaker identification and keyword spotting. *FY 2010 Plans:* - Develop robust automatic speech transcription and translation algorithms for use in adverse environments (those with noise, distortion, reverberation, and/or competing speech signals). - Develop noise suppression and speech exploitation based on multi-microphone arrays. - Refine new speech processing techniques for noisy environments, including echo suppression, speech activity detection, language identification, speaker identification and keyword spotting. *FY 2011 Base Plans:* - Optimize new speech processing techniques for noisy environments, including echo suppression, speech activity detection, language identification, speaker identification and keyword spotting. - Plan for transition of technologies developed through RATS into high-impact military systems and intelligence operations centers.					
Accomplishments/Planned Programs Subtotals	75.244	66.787	52.341	0.000	52.341

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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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	122.810	144.236	90.143	0.000	90.143	88.462	87.592	86.773	91.963	Continuing	Continuing
COG-02: *COGNITIVE COMPUTING*	81.549	99.825	54.641	0.000	54.641	46.460	44.090	48.022	48.212	Continuing	Continuing
COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	41.261	44.411	35.502	0.000	35.502	42.002	43.502	38.751	43.751	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Cognitive Computing Systems program element is budgeted in the Applied Research budget activity because it is developing the next revolution in computing and information processing technology that will enable computational systems to have reasoning and learning capabilities and levels of autonomy far beyond those of today's systems. The ability to reason, learn and adapt will raise computing to new levels of capability and powerful new applications.

(U) The Cognitive Computing project will develop core technologies that enable computing systems to learn, reason and apply knowledge gained through experience, and respond intelligently to things that have not been previously encountered. These technologies will lead to systems demonstrating increased self-reliance, self-adaptive reconfiguration, intelligent negotiation, cooperative behavior and survivability with reduced human intervention.

(U) The Collective Cognitive Systems and Interfaces Project will dramatically improve warfighter and commander effectiveness and productivity using advanced cognitive approaches that enable faster, better informed, and more highly coordinated actions than those of our enemies. This will be accomplished by developing revolutionary methods that increase our information processing capabilities, enhance our situational awareness, and enable more cohesive group action by our forces. Critical technical areas addressed in this project include automated coordinated decision support, information sharing, and ensured communications.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	144.869	142.840	0.000	0.000	0.000
Current President's Budget	122.810	144.236	90.143	0.000	90.143
Total Adjustments	-22.059	1.396	90.143	0.000	90.143
• Congressional General Reductions		-0.604			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	-6.989	0.000			
• Congressional Adds		2.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-11.000	0.000			
• SBIR/STTR Transfer	-4.070	0.000			
• TotalOtherAdjustments	0.000	0.000	90.143	0.000	90.143

Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2009	FY 2010
Project: COG-02: *COGNITIVE COMPUTING*		
Congressional Add: *BioButanol Production Research*	0.000	2.000
Congressional Add Subtotals for Project: COG-02	0.000	2.000
Congressional Add Totals for all Projects	0.000	2.000

Change Summary Explanation

FY 2009
Decrease reflects Omnibus Reprogramming action for the H1N1 vaccine development, SBIR/STTR transfer, and the Section 8042 rescission of the FY 2010 Appropriation Act.
FY 2010
Increase reflects the congressional adds (as identified above) offset by the Section 8097 Economic Assumption.
FY 2011
Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency			DATE: February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
COG-02: *COGNITIVE COMPUTING*	81.549	99.825	54.641	0.000	54.641	46.460	44.090	48.022	48.212	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Cognitive Computing project will develop core technologies that enable computing systems to learn, reason and apply knowledge gained through experience, and to respond intelligently to new and unforeseen events. These technologies will lead to systems with increased self reliance, cooperative behavior, and the capacity to reconfigure themselves and survive with reduced programmer intervention. These capabilities will make the difference between mission success and mission degradation or failure, even in the event of cyber-attack or component attrition resulting from kinetic warfare or accidental faults and errors. Systems that learn and reason will reduce the requirement for skilled system administrators and dramatically reduce the overall cost of system maintenance. As the military moves towards a dynamic expeditionary force, it is critical for systems to become more self sufficient.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Personalized Assistant that Learns (PAL) (U) The Personalized Assistant that Learns (PAL) program enables intelligence in information processing systems so that critical DoD systems can better support the warfighter. PAL systems will have embedded learning capabilities that will allow them to retain prior learned knowledge, apply this knowledge to new scenarios and ultimately provide faster and more effective assistance. Overall, the ability to learn will enable the performance of a PAL system to improve over time. Cognitive systems technologies developed in this program will be applied and demonstrated in ongoing and future Command and Control Systems programs. (U) The PAL program is creating the first comprehensive system that will dramatically empower commanders to understand all aspects of the current military situation, radically reduce manpower and labor required in command posts and in the field, and automate the massive number of administrative and analytical tasks characteristic of today's command centers. PAL capabilities will result in the ability	27.344	26.275	16.298	0.000	16.298

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
to turn diverse, multi-source data into actionable information for commanders and warfighters; dramatic manpower reductions; corporate memory retention of both the larger conflict history and the history of each specific command center; and intelligent information presentation. (U) PAL will create an intelligent desktop assistant that enables users to create and share routines to discover, manipulate, and exploit data, services and web content. This work will extend the emerging web services paradigm to produce semantically-enabled search and processing capabilities that make it easier to find information on the Internet and get it into the form a user needs. Ultimately this work will yield cognitive search agents that greatly reduce the time it takes users to find and process information. *FY 2009 Accomplishments:* - Developed a dialogue system with general and domain-specific semantics for eliciting natural language advice from the warfighter and other end users of PAL technology and PAL-enhanced systems. - Extended, improved, and optimized PAL technology based on initial user feedback. *FY 2010 Plans:* - Fine tune all algorithms for scale-up, response time and throughput. - Finalize human-computer interface and complete the debugging of all PAL software. - Develop the ability for an integrated cognitive system such as PAL to model its own behavior. - Create the ability for cognitive systems to exchange locally-learned knowledge. *FY 2011 Base Plans:* - Extend dialogue capability to enable user-defined extensions to descriptions of Web semantics. - Develop and demonstrate cognitive agents that greatly reduce the time it takes users to find and process information on the World Wide Web.					
Integrated Learning	10.317	8.276	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Integrated Learning program is creating a new computer learning paradigm in which systems learn complex workflows from warfighters while the warfighters perform their regular duties. The effort is focused on military planning tasks such as air operations center planning and military medical logistics. With this learning technology, it will be possible to create many different types of military decision support systems that learn by watching experts rather than relying on expensive and error prone hand-encoded knowledge. The new learning paradigm differs from conventional machine learning in that it does not rely on large amounts of carefully crafted training data. Rather, in the new paradigm the learner works to “figure things out” by combining many different types of learning, reasoning, and knowledge. Such a cognitive system will ultimately need the capability to build and update its own internal model of the world and the objects in it without human input. *FY 2009 Accomplishments:* - Modified the integrated learning systems so they can incorporate new software components dynamically and utilize the new capabilities while learning. - Created control algorithms for the systems that manage credit-and-blame assignment on a component-by-component basis so that if conflicts arise the system can reason about which piece of conflicting information is more likely to be accurate. - Created control algorithms that reason about the costs/benefits of resolving a particular conflict and direct system performance accordingly. - Evaluated systems by having them compete against expert humans. *FY 2010 Plans:* - Expand the scope of the problems being learned so the systems learn multi-user task models. - Modify the integrated learning systems to be able to abstract the details of the process it is learning and learn general process or meta process knowledge. - Extend capabilities of the integrated learning systems so they can share information (low-level data, mid-level hypothesis, and high-level conclusions) with other learners. - Evaluate systems by having them compete against expert humans.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Bootstrapped Learning	9.081	8.650	0.000	0.000	0.000
(U) The Bootstrapped Learning program will provide computers with the capability to learn complex concepts the same way people do: from a customized curriculum designed to teach a hierarchy of concepts at increasing levels of complexity. Learning each new level depends on having successfully mastered the previous level's learning. In addition, the learning program will be “reprogrammable” in the field using the same modes of natural instruction used to train people without the need for software developers to modify the software code. At each level, a rich set of knowledge sources (such as training manuals, examples, expert behaviors, simulators, and references and specifications that are typically used by people learning to perform complex tasks) will be combined and used to generate concepts and a similar set of knowledge sources for the next level. This will enable rapid learning of complex high-level concepts, a capability which is essential for autonomous military systems that will need to understand not only what to do but, why they are doing it, and when what they are doing may no longer be appropriate. *FY 2009 Accomplishments:* - Developed a single system capable of being instructed to perform in three diverse domains. - Demonstrated the ability of a system to repeatedly acquire new knowledge that drives future learning and cumulatively adds to the system’s knowledge. - Validated through simulation that diagnosis, configuration and control of critical, autonomous military hardware can be addressed with bootstrapped learning technology. *FY 2010 Plans:* - Establish incontrovertible system generality by demonstrating learning performance in a “surprise” domain that is completely unknown to the learning system developers. - Enhance system capabilities to include instructible situational awareness.					
Machine Reading and Reasoning Technology	7.807	18.638	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Machine Reading and Reasoning Technology program will develop enabling technologies to acquire, integrate, and use high performance reasoning strategies in knowledge-rich domains. Such technologies will provide DoD decision makers with rapid, relevant knowledge from a broad spectrum of sources that may be dynamic and/or inconsistent. To address the significant challenges of context, temporal information, complex belief structures, and uncertainty, new capabilities are needed to extract key information and metadata, and to exploit these via context-capable search and inference (both deductive and inductive). Machine reading addresses the prohibitive cost of handcrafting information by replacing the expert, and associated knowledge engineer, with un-supervised or self-supervised learning systems that "read" natural text and insert it into AI knowledge bases especially encoded to support subsequent machine reasoning. Machine reading requires the integration of multiple technologies: natural language processing must be used to transform the text into candidate internal representations, and knowledge representation and reasoning techniques must be used to test this new information to determine how it is to be integrated into the system's evolving models so that it can be used for effective problem solving. These concepts and technology development efforts will continue in PE 0602305E, Project MCN-01 beginning in FY 2011. *FY 2009 Accomplishments:* - Initiated research into techniques for reasoning with ambiguous and conflicting information found in texts. - Extended knowledge representation to support machine reading of large (e.g. open source web) amounts of material with the goal of encoding and querying at broad but shallow semantic levels. - Produced domain representations that enable semi-supervised approaches to knowledge acquisition. *FY 2010 Plans:* - Demonstrate the ability of a system to acquire and organize factual information directly from unstructured narrative text in multiple domains.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop knowledge representation and reasoning capabilities to support simple temporal reasoning using ordered relationships in text. - Demonstrate the ability of machine reading systems to extract knowledge from texts that employ varied writing styles and require contextualization for proper interpretation.					
Foundational Learning Technology	10.000	14.196	13.843	0.000	13.843
(U) The Foundational Learning Technology program develops advanced machine learning techniques that enable cognitive systems to continuously learn, adapt and respond to new situations by drawing inferences from past experience and existing information stores. The techniques developed under Foundational Learning Technology address diverse machine learning challenges in processing of sensory inputs, language acquisition, combinatorial algorithms, strategic analysis, planning, reasoning, and reflection. One very promising approach involves transfer learning techniques that transfer knowledge and skills learned for specific situations to novel, unanticipated situations and thereby enable learning systems to perform appropriately and effectively the first time a novel situation is encountered. This is essential because most military operations occur in ever-changing environments; U.S. forces and systems must be able to act appropriately and effectively the first time each novel situation is encountered. *FY 2009 Accomplishments:* - Demonstrated the ability of agents to learn in a visual domain and apply the knowledge to solve problems in an action domain such as robotic grasping. - Demonstrated improved entity extraction performance with multiple languages and styles of writing by transferring knowledge between problem classes. *FY 2010 Plans:* - Formulate learning approaches applicable to processing of sensory inputs. - Develop techniques to enable generalization of knowledge across application areas such as language acquisition, strategic analysis, planning, reasoning, and reflection.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Implement and test machine learning approaches on selected problems in processing of sensory inputs, language acquisition, strategic analysis, planning, reasoning, and reflection. - Explore concepts for universal emergent reasoning built from rich, embedded interaction directed by multiple instincts and drives. - Conceptualize new non-symbolic formulations that exploit multiple sources of constraint, feedback, and guidance to address more complex tasks.					
Robust Robotics (U) The Robust Robotics program is developing advanced robotic technologies that will enable autonomous (unmanned) mobile platforms to perceive, understand, and model their environment; navigate through complex, irregular, and hazardous terrain; manipulate objects without human control or intervention; make intelligent decisions corresponding to previously programmed goals; and interact cooperatively with other autonomous and manned vehicles. These capabilities will enable robotic vehicles to support warfighters in diverse environments including urban, ground, air, space, and underwater. A key objective is intelligent control of mobile manipulators to independently perform subtasks over a broad range of domains of interest to the warfighter, thereby reducing operator workload, time on target, training time, bandwidth, and hardware complexity. Another key objective is robust navigation and locomotion even in the absence of GPS, since this underlies the ability to move through the difficult and unpredictable terrain of theater operations, which may include highly irregular and mountainous areas, partially-destroyed roads, rubble-filled urban terrain, and other vehicles and personnel. Robust Robotics is also developing techniques for robots to perform in dynamic environments by improving robotic vision and scene understanding. This includes the capability to predict the future location and even the intent of moving objects in order that robots can handle both movement and clutter simultaneously and plan a collision-free course through the environment. Future autonomous systems must also achieve a much higher autonomy level when performing complex tasks, and so Robust Robotics is developing techniques that will enable robotic agents to achieve	15.000	16.490	20.500	0.000	20.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
effective levels of autonomous reasoning whether humans are present or not. Future robotic agents must also be able to effectively perform when they are part of a team and assume semi-independent roles across a variety of activities. This will be achieved by developing robotic systems that can accept and understand instructions to define new activities and their variants from human controllers. *FY 2009 Accomplishments:* - Created new and modified existing learning algorithms to enable legged laboratory robots (small scale versions of operational sized platforms) to run over terrain at speeds proportional to humans. - Evaluated the new learning algorithms on a series of different terrain settings in a competitive fashion. - Prepared learning locomotion algorithms to port to larger scale vehicles to increase mobility of larger scale robots. - Created learning locomotion toolkits that control a diverse set of high-degree-of-freedom vehicles on rough terrain. *FY 2010 Plans:* - Develop representations and algorithms to track and classify moving objects despite extensive occlusion and poor GPS coverage. - Develop reasoning techniques for dynamic environments that predict non-deterministic mover behaviors given noisy estimates of mover velocity and unreliable tracking due to occlusions. - Develop motion planning algorithms for cluttered, dynamic environments. - Develop a mobile manipulator--a four-wheeled mobile base and two arms, each with multi-fingered hands--to serve as a common development platform. - Develop controllers that simultaneously manage the degrees of freedom from the base and from the arms and hands.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Refine motion understanding by combining geometry and recognition to establish object identity over time. - Refine reasoning techniques to predict object motion based on object type, intent, mover dynamics, and scene configuration. - Develop techniques for handling adversarial (actively impeding robot) movers. - Develop bi-manual manipulation primitives for handling deformable materials, such as opening a satchel with one hand holding a handle and the other zipping a zipper or opening a clasp. - Develop kinesthetic search techniques based on tactile and haptic sensing.					
Biomimetic Computing (U) Biomimetic Computing's goal is to develop the critical technologies necessary for the realization of a cognitive artifact comprised of biologically derived simulations of the brain embodied in a mechanical (robotic) system, which is further embedded in a physical environment. These devices will be a new generation of autonomous flexible machines that are capable of pattern recognition and adaptive behavior and that demonstrate a level of learning and cognition. Key enabling technologies include simulation of brain-inspired neural systems and special purpose digital processing systems designed for this purpose. *FY 2009 Accomplishments:* - Created a special purpose processor and associated assembly language to enable systems to have one million neuronal processing units. - Created simulations of complex neural dynamics found in brains including the spontaneous formation of neural groups with short term memory capacity. - Demonstrated a first-generation, knuckle-walking, ape-inspired robotic platform with complex sensing and actuation capabilities (wirelessly) connected to a large computer cluster simulating the neural system attached to the robotic sensors and actuators.	2.000	5.300	4.000	0.000	4.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop the capability to simulate a system of one million thalamocortical neurons with spike time dependent plasticity connected to an ape-inspired robot. - Investigate the ability of the robot and simulated neural system to organize its visual system and associate sensory inputs and motor output. - Improve and extend neural system models to include capabilities to make decisions on the basis of reward in the environment and internal value systems. *FY 2011 Base Plans:* - Demonstrate an autonomous robot with a simulated neural system capable of mentally rotating images in order to grasp complex three dimensional objects.					
Accomplishments/Planned Programs Subtotals	81.549	97.825	54.641	0.000	54.641

	FY 2009	FY 2010
Congressional Add: BioButanol Production Research *FY 2010 Plans:* - Continue to investigate bio-butanol production capabilities.	0.000	2.000
Congressional Adds Subtotals	0.000	2.000

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	**PROJECT** COG-02: *COGNITIVE COMPUTING*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	41.261	44.411	35.502	0.000	35.502	42.002	43.502	38.751	43.751	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Collective Cognitive Systems and Interfaces project will dramatically improve warfighter and commander effectiveness and productivity using advanced cognitive approaches that enable faster, better informed, and more highly coordinated actions than those of our enemies. This will be accomplished by developing revolutionary methods that increase our information processing capabilities, enhance our situational awareness, and enable more cohesive group action by our forces. Critical technical areas addressed in this project include automated decision support, information sharing, and ensured communications. Cognitive decision support tools reason about tasks, timings, and interactions so that when plans change or the enemy does not respond as anticipated, U.S. forces can quickly adapt. The quality of such decisions and the effectiveness of our actions depend critically on our ability to take full advantage of all available information in a rapid and flexible manner. This requires the capability to share information and to automatically integrate distributed information bases for broad tactical battlespace awareness. Finally, team cohesion requires effective and reliable communication in difficult environments such as urban settings where radio signal propagation is complex. Here the approach is to develop cognitive communications management and control algorithms that reason about channel conditions, higher-level application connectivity requirements and related factors, and decide (often as a group) what parameters each radio will use. The suite of programs under this project will significantly advance the military's ability to successfully deal with complex situations in operational environments.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Advanced Soldier Sensor Information System and Technology (ASSIST)*	11.633	9.450	7.000	0.000	7.000
*Formerly a part of Collaborative Cognition. (U) The Advanced Soldier Sensor Information System and Technology (ASSIST) effort will develop an integrated information system that exploits soldier-worn sensors to augment the soldier's ability to capture, report, and share information in the field. This includes an integrated system using advanced technologies for processing, digitizing and analyzing information captured and collected by soldier-worn					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
sensors. ASSIST draws heavily on the experiences and lessons learned from previous Operation Iraqi Freedom (OIF) missions and other surveillance and reconnaissance missions. A baseline system will demonstrate the capture of video/still images together with voice annotations and location-stamping. The advanced system will demonstrate automatic identification and extraction of key objects, events, activities and scenes from soldier-collected data. The system will create knowledge representations that will serve as an input to an array of warfighter products including augmented maps, situational analysis tools, and query and answer capabilities. Real-time data collection and analysis of civilian interviews and field observations will facilitate understanding of the local and regional political, social, economic, and infrastructure situation for both dismounted soldiers on patrol and battalion/brigade-level analysts. *FY 2009 Accomplishments:* - Established a Memorandum of Agreement with the U.S. Army to delineate the transition of the Tactical Ground Reporting System (TIGR) to a program of record, as well as a three-year schedule for transition. - Demonstrated real-time reporting using on-soldier sensors and an intuitive information push/pull user interface. - Addressed the technical challenges associated with providing ASSIST as a real-time capability for the dismounted soldier in the field. - Integrated ground sensor “Street View” data and manipulation capability into TIGR. - Developed components that enable in-field data sharing and retrieval on a wearable computing/ sensor platform. - Demonstrated eyes-free, hands-free, attention-free collection of key events and experiences for reporting. - Demonstrated tools for analyzing blue-force and red-force trends and patterns. *FY 2010 Plans:* - Develop the means for efficient transfer of ASSIST information across Army Tactical Networks.					

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APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	**PROJECT** COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Integrate multiple, real-time sensor feeds including high-bandwidth sensor feeds such as video streams. - Integrate with Army Battlefield Command Systems, including consideration of system latencies, and data exchange formats and modalities. - Demonstrate the system's ability to improve its event and object classification performance through learning. - Demonstrate an accelerated capability for recognizing new classes of events, objects and activities. - Develop and demonstrate a real-time variant for use by dismounted soldiers, with enhancements that include video feeds from airborne platforms. - Integrate advanced multimodal sensor event and object extraction techniques and evaluate the enhanced capabilities. - Integrate biometric feature extraction and comparison capabilities into TIGR. - Automate the extraction of relevant portions of feeds for indexing into the TIGR database. *FY 2011 Base Plans:* - Implement robust operation over wireless networks of very limited bandwidth. - Develop prototype operation on hardware of limited capability. - Demonstrate enhanced capability in the ingest and extraction of multimodal sensor events and objects. - Develop real-time collaboration tools for dismounted soldiers. - Develop fast, graph-based, information analysis algorithms that can run on handheld devices in the field. - Develop techniques for real-time analysis to identify knowledge gaps, provide information on the individuals being interviewed, and generate information requests.					
Cognitive Networking (U) The Cognitive Networking program will develop technologies that provide information systems and communication networks with the ability to maintain and self-optimize their own functionality, reliability	22.075	16.459	7.502	0.000	7.502

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and survivability. These technologies will allow the military to focus its critical manpower resources on the mission rather than on the maintenance of its information systems and network infrastructure. Cognitive information processing will be used to optimize networked communications based on current conditions, past experience and high-level user guidance. The Cognitive Networking program is also addressing the warfighter's need for actionable situational awareness in complex radio frequency (RF) environments. This work leverages advances in software-defined radio technology to achieve specific military goals. The program has interest in machine learning techniques that can enhance the effectiveness of jamming and other RF countermeasures. So-called "cognitive jamming" has the potential to deny the enemy's effective use of the RF spectrum. The Cognitive Networks effort funds three programs: SAPIENT, LANDroids, and BOSS. • The Situation-Aware Protocols in Edge Network Technologies (SAPIENT) effort will develop a new generation of cognitive protocol architectures to replace conventional protocols that fare poorly in extreme network conditions and do not provide adequate service for key applications. Technology developed in the SAPIENT effort will have military utility wherever tactical communications are deployed. SAPIENT architectures will represent awareness with a knowledge base that is updated based on specification and observation. SAPIENT technology enables the automatic adaptation of protocols to the operational environment to dramatically reduce the effect of network impairments on applications while demonstrating a positive trend in capability as new situations are encountered and learned. • The Local Area Network droids (LANdroids) effort will give warfighters reliable communications in urban settings. LANdroids will accomplish this by creating robotic radio relay nodes that move autonomously to configure and maintain a communications mesh by reasoning about their positions relative to one another and relative to the warfighters. LANdroids will move as the warfighters move with the goal of maintaining warfighter connectivity throughout their operations. LANdroids will be pocket-sized so warfighters can carry several and drop or deploy them as they move through an area.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
The effort is creating both the intelligent radio control software and the small radio platform on which it runs. The technologies will be tested in a physical setting and at an operationally relevant scale. • The Brood of Spectrum Supremacy (BOSS) effort will provide actionable situational awareness to the warfighter in complex radio frequency (RF) environments. BOSS adds collaborative processing capabilities to tactical software-defined radios to achieve specific military goals. BOSS exploits cooperative use of computational, communication and sensory capabilities in a software radio, in aggregate, to generate breakthrough capabilities in the warfighter knowledge of their surroundings, with a particular focus on RF-rich urban operations. Machine learning techniques will enable real-time characterization of an adversary's radio dynamics and provide cognitive, networked responses to new enemy threats. Ultimately this effort will develop Software Communications Architecture (SCA)-compliant waveforms suitable for implementation on a tactical software radio system. *FY 2009 Accomplishments:* Situation-Aware Protocols in Edge Network Technologies (SAPIENT) - Integrated and enhanced the prototypes by expanding link handling, and evaluated their performance. - Implemented a functional cognitive learning system that facilitates real-time selection and composition of protocols. - Updated protocol stack composition components and adapted the cognitive engine implementation to use the new protocol components. Local Area Network droids (LANdroids) - Evaluated a 10-node LANdroids network with respect to self-configuration, self-optimization and self-healing. Brood of Spectrum Supremacy (BOSS) - Developed high-accuracy, RF geolocation algorithms for embedding into RF devices of interest.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Performed field measurements for verification of RF geolocation algorithms. - Established contracts to enable the use of the radios developed on the DARPA Wireless Network after Next (WNaN) program for use with the BOSS program. *FY 2010 Plans:* Situation-Aware Protocols in Edge Network Technologies (SAPIENT) - Demonstrate an adaptive cognitive prototype for a tactical environment using mobile, airborne, and stationary nodes. Local Area Network droids (LANdroids) - Evaluate tethering, power management and load-balancing algorithms using a 15-node LANdroids network that spans two indoor floors of a building. - Develop control algorithms for LANdroids that enable them to tether the network to warfighters so the network moves as the warfighters move. - Develop intelligent power management algorithms for LANdroids so they make intelligent decisions about whether or not to move based on current conditions and expected power expenditures and savings. - Develop network load-balancing protocols for LANdroids that dovetail with the power management algorithms to enable the network to last as long as possible. Brood of Spectrum Supremacy (BOSS) - Collect RF data with WNaN radio to evaluate BOSS algorithms with these radios. - Perform minor modifications on the WNaN radio to extend the frequency range for BOSS applications. This will enable BOSS to be used with a wider range of signals of interest. - Optimize BOSS software as necessary for use with WNaN radios. - Begin embedding the BOSS algorithms into radios for real-time testing and evaluation. - Evaluate network understanding algorithms with collected RF data.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: Brood of Spectrum Supremacy (BOSS) - Complete implementation of BOSS capabilities utilizing WNaN radios with BOSS frequencies. - Test and evaluate BOSS real-time performance in “real-world” scenarios. This includes testing and evaluation of RF geolocation performance and network understanding performance.					
Cloud Computing (U) Cloud Computing is a technique to enable information, applications, services, storage, and other resources that reside on military networks to be used by web-based clients to perform critical mission functions. The Cloud Computing program will create architectures to automatically integrate distributed information bases for broad tactical battlespace awareness. The Cloud Computing program will produce the infrastructure and application technologies needed to automate the integration of multiple media (text, video, and digital photographs) as well as its analysis, indexing, and storage so that it can be easily queried and retrieved by users across the DoD enterprise. Inherent to such ubiquitous availability of enterprise data is the need for strong security including fine-grained/role-based access controls. The concepts and technology will continue in PE 0602305E, Project MCN-01 under Web-Scale Information Integration. • The Digital Object Storage and Retrieval (DOSR) effort is pursuing a network-based approach to information storage and management that will enable a network-based repository to hold all digital information. The DOSR repository will reside on the network and provide a mechanism for the virtual (i.e., logical, not physical) centralization of all enterprise information. DOSR technology will enable and facilitate controlled access to information by approved and authenticated users across administrative domains, and in this fashion it will enable transparent sharing of information across the enterprise. Repositories built on DOSR technology will, in addition, provide a single distributed platform/framework for additional document/content/information services including indexing, metadata creation, search,	7.553	5.502	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
versioning, and records management, resulting in the warfighter's ability to take full advantage of all available pertinent information in a rapid and flexible manner. • The Data Integration and Exploitation SystEm that Learns (DIESEL) effort will address a significant problem facing the warfighter: the lack of interoperability of stovepiped information systems. DIESEL will create a new suite of intelligent information integration tools that will learn to automatically understand heterogeneous information systems and integrate them into the existing information environment. The result will be more complete and reliable information as the basis for better decision-making for warfighters. *FY 2009 Accomplishments:* Digital Object Storage and Retrieval (DOSR) - Developed and refined concepts for the repository architecture. - Prototyped subsystems that address access control and security in a networked environment and support a public/private key infrastructure (PKI) as a means of authentication. - Prototyped subsystems that address the intelligent search and access of heterogeneous information. - Prototyped subsystems to support intermittently connected operations. Data Integration and Exploitation SystEm that Learns (DIESEL) - Demonstrated preliminary ideas for learning-based entity resolution, data source modeling, and schema mapping technologies. - Evaluated automated alignment and translation technology through tests with realistic military information systems and a variety of new data sources. - Designed an automated system to evaluate the accuracy of new, unknown data sources such as confiscated hard drives with questionable provenance. *FY 2010 Plans:* Digital Object Storage and Retrieval (DOSR)					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Design a method for controlled, secure access across administrative domains and its potential for integrating diverse, distributed information bases. - Design subsystems for a distributed platform enabling information search, access, and proactive distribution of information based on user models and provenance to enhance availability and support intermittently connected operations. - Demonstrate secure, geographically distributed and replicated storage with superior retrieval performance characteristics. Data Integration and Exploitation SystEm that Learns (DIESEL) - Design user models based on the task to be performed (aided by the Army's Tactics, Techniques, and Procedures manuals), which will provide semantic context to refine search results. - Integrate with existing automated visualization services to provide 'at a glance' understanding of relevant content, customized to the user and task. - Design an automated data integration technology through tests with realistic military information systems and a variety of new data sources of increasing complexity.					
Transformative Apps (U) The goal of the Transformative Apps effort is to put mobile, tactical applications (apps) in the hands of warfighters and to create a new military apps marketplace with a vibrant apps development community. The effort will demonstrate a broad array of apps supporting command and control, enhanced situational awareness, collaboration, geo-spatial visualization, training, and language translation. Many of the applications will require ongoing network connectivity; other applications will require occasional data synchronization. While commercial networks benefit from robust cellular networks and the presence of large data centers, tactical networks are notorious for their limited bandwidth, frequent outages, and high-latency links. Specialized backend architecture and middleware will be developed to enable apps to run while providing optimal user experience and without over-burdening the network. Of particular importance is new data synchronization architecture between the handhelds and the backend computing/storage nodes. Additionally, appropriate middleware	0.000	7.000	12.000	0.000	12.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
services and libraries will be developed to facilitate shared capabilities such as map viewing, apps management, and collection of logs, usage statistics and user feedback. Apps, together with handhelds and networks, will be tested in different training environments as well as in deployed environments. Performance and usage will be carefully tracked and user feedback collected to guide rapid enhancement of apps. The effort will create a vibrant apps development community by aggressively reaching out to non-traditional performers and will explore new models for software acquisitions based on end-user empowerment. The effort will leverage the resources, experience, and lessons-learned derived from the Tactical Ground Reporting System (TIGR). *FY 2010 Plans:* - Launch a series of user conferences. - Establish innovation and collaboration tools. *FY 2011 Base Plans:* - Develop initial set of middleware services and tools. - Develop initial apps suite available on BETA repository. - Perform operational evaluation testing with military and commercial networks.					
Healing Heroes (U) Healing Heroes will bring the power of social networking, modern information technology, and machine learning to bear on the medical problems facing America's veterans by creating the infrastructure for a social networking site where veterans can share their medical experiences and find mutual support. In addition, Healing Heroes will connect active duty service members, veterans, and their families to the military medical establishment to facilitate the flow of information between care-givers and patients. Natural language processing and advanced machine learning techniques will be implemented to quickly alert caregivers to any emerging physical or mental health crisis based on a patient's medical history and the content and nature of their social interaction. Healing Heroes will be implemented using strong information security to ensure its confidentiality, integrity, and availability.	0.000	6.000	9.000	0.000	9.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop core Healing Heroes functional and security services. - Implement initial Healing Heroes infrastructure in preparation for 1000 member alpha test/user trial. *FY 2011 Base Plans:* - Perform 1000member alpha test/user trial. - Complete development of Healing Heroes functional and security services. - Implement complete Healing Heroes infrastructure in preparation for 10,000 member beta test/user trial.					
Accomplishments/Planned Programs Subtotals	41.261	44.411	35.502	0.000	35.502

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602305E: *MACHINE INTELLIGENCE*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	0.000	0.000	44.682	0.000	44.682	68.972	69.498	68.802	68.414	Continuing	Continuing
MCN-01: *MACHINE INTELLIGENCE*	0.000	0.000	44.682	0.000	44.682	68.972	69.498	68.802	68.414	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Machine Intelligence project is budgeted in the Applied Research Budget Activity because it is developing technologies that will enable computing systems to extract and encode information from dynamic and stored data, observations, and experience, and to derive new knowledge, answer questions, reach conclusions, and propose explanations. Enabling computing systems with machine intelligence in this manner is now of critical importance because sensor, information, and communication systems continuously generate and deliver data at rates beyond which humans can assimilate, understand, and act. Since its creation over 50 years ago, artificial intelligence (AI) has gone through several phases. Initially, AI emphasized rule-based and symbolic approaches. These were eventually reconceived using a human-intelligence paradigm (“cognitive computing”). Recently, a more powerful approach has emerged, with rule-based, symbolic and human-oriented approaches combined with large-scale statistical approaches that make explicit use of massive distributed data and information bases. These data/information bases are curated (e.g., machine-filtered or human-selected) and raw (e.g., as originally obtained and perhaps of unknown provenance); structured (e.g., tabular or relational) and unstructured (e.g., text documents, multi-media files); static (e.g., historical, unchanging) and dynamic (e.g., real-time sensor data). This explosion in available data/information, combined with the ready availability of inexpensive mass storage and ubiquitous, inexpensive, computation-on-demand, provide the foundation for entirely new machine intelligence capabilities. The technologies developed in the Machine Intelligence project will result in revolutionary capabilities in military command and control, intelligence, decision-making, and situational awareness/indications and warning for a complex, global environment where traditional (e.g., nation-states) and non-traditional (e.g., trans-national) actors and new classes of cyber-physical-human threats have become the status quo.

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APPROPRIATION/BUDGET ACTIVITY	**R-1 ITEM NOMENCLATURE**
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	PE 0602305E: *MACHINE INTELLIGENCE*

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	0.000	0.000	44.682	0.000	44.682
Total Adjustments	0.000	0.000	44.682	0.000	44.682
• Congressional General Reductions		0.000			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• TotalOtherAdjustments	0.000	0.000	44.682	0.000	44.682

Change Summary Explanation

FY 2011
Not Applicable

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Machine Reading and Reasoning Technology (U) The Machine Reading and Reasoning Technology program (previously funded in PE 0602304E, Project COG-02) will develop enabling technologies to acquire, integrate, and use high performance reasoning strategies in knowledge-rich domains. Such technologies will provide DoD decision makers with rapid, relevant knowledge from a broad spectrum of sources that may be dynamic and/or inconsistent. To address the significant challenges of context, temporal information, complex belief structures, and uncertainty, new capabilities are needed to extract key information and metadata, and to exploit these via context-capable search and inference. Cognitive inference has traditionally	0.000	0.000	23.896	0.000	23.896

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
emphasized deduction via theorem-proving and induction via statistical techniques, but abduction — also known as “inference to the best explanation”— is also likely to play a large role. DoD systems sense, capture, and store information in the form of text, audio, imagery, and video, and so advanced machine reasoning capabilities must extract knowledge from, and reason about, all types of multimedia data. New visual faculties will enable cognitive systems to learn from visual experience, to reason about action in the real world, and to apply that knowledge in a broad range of domains to solve problems in tactical and security contexts. (U) Machine Reading addresses the prohibitive cost of handcrafting information by replacing the expert, and associated knowledge engineer, with un-supervised or self-supervised learning systems, systems that “read” natural text and insert it into AI knowledge bases, i.e. data stores especially encoded to support subsequent machine reasoning. Machine Reading requires the integration of multiple technologies: natural language processing must be used to transform the text into candidate internal representations, and knowledge representation and reasoning techniques must be used to test this new information to determine how it is to be integrated into the system’s evolving models so that it can be used for effective problem solving. *FY 2011 Base Plans:* - Extend knowledge extraction capabilities of machine reading systems to acquire simple relationship information in addition to factual data. - Force generality of machine reading systems through introduction of multiple, hidden domains. - Develop knowledge extraction, representation, and reasoning capabilities to support spatial, complex temporal, and event reasoning. - Develop an abductive inference system that discovers explanatory relationships between formal assertions without need of formal proof. - Integrate new visual reasoning components into a complete architecture that combines visual concept learning, analysis, and imagination with facilities for low-level visual processing, cognition, and user/system interfaces.					

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Web-Scale Information Integration (U) The Web-Scale Information Integration program (formerly funded as Cloud Computing in PE 0602304E, Project COG-03) will create technologies to automatically integrate distributed information bases for broad strategic and tactical battlespace awareness, including technologies to automate the integration of multiple media (text, video, and digital photographs) as well as analyze, index, and store that media, so that it can be easily queried and retrieved by users across the DoD enterprise. A key enabler is the creation of a network-based repository that provides a mechanism for the virtual (i.e., logical, not physical) centralization of all enterprise information. This concept is well-aligned with important developments in the commercial sector related to cloud computing, which makes computing resources and services readily available over the Internet ("public cloud") or enterprise intranet ("private cloud"). Inherent to such ubiquitous availability of enterprise data is the need for strong security including fine-grained/role-based controls that enable and facilitate access only to approved and authenticated users. A second key enabler is the development of advanced document/content/information-object services including indexing, metadata creation, search, versioning, records management, schema alignment, and information visualization. Program interest extends to semantic web technologies whereby the semantics of information and services are made explicit, enabling machines to understand and satisfy the information requests of users (people and machines). This will provide the basis for semantically-enabled search and processing capabilities that automate information discovery and manipulation. The Web-Scale Information Integration program will also create a new suite of intelligent information integration tools that will learn to automatically understand heterogeneous information systems and integrate them into the existing information environment. In this fashion the Web-Scale Information Integration program will enable virtual interoperability of information systems that are currently stovepiped. The result will be more complete and reliable information as the basis for better decision-making for warfighters.	0.000	0.000	13.786	0.000	13.786

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602305E: *MACHINE INTELLIGENCE*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Conceptualize a distributed information architecture that can scale to petabytes of storage, quadrillions of objects and metadata tags, tens of thousands of network nodes, and millions of end-user processors. - Develop highly efficient techniques for metadata extraction, user modeling, network pre-positioning of information resources, provenance tracking, and version control. - Integrate dialogue system with semantically-enabled search capabilities to enable intelligent, user-defined Web search routines. - Link dialogue semantics with learning-by-demonstration techniques to produce reusable and composable Web search and content manipulation services. - Develop ability to align disparate data sources to provide a centralized query capability and construct an interactive visualization to increase an analyst's understanding of the disparate data sources. - Construct a small-scale testbed on which to conduct testing with actual military information systems and a variety of new data sources of increasing complexity.					
Large-Scale Asymmetric Systems (U) The Large-Scale Asymmetric Systems program will develop intelligent situational assessment technologies that will enable us to understand, anticipate, prevent and counter current, emerging, and potential threats to our military at the global, regional and local scales. Examples of such threats include emerging regional peer rivals, rogue and failed nation-states, insurgent groups, militant/radicalized populations, and trans-national terrorist organizations and criminal enterprises. An intelligent situation assessment system would process and integrate data/information from physical sensors and non-physical sources to derive the likely probabilities of the range of outcomes for a variety of interactions involving complex cyber-physical-human networks. In addition, an intelligent situation assessment system would provide indications and warning of asymmetric threats while they are still at the stage where they can be managed by peaceful means and before they require a military response. Large-Scale Asymmetric Systems will use cognitive and computational technologies to	0.000	0.000	7.000	0.000	7.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
produce quantitative and qualitative models that enable the assessment of alternative courses of action and anticipation of system dynamics including diplomatic, information, military, and economic (DIME) actions. This will include the development of operationally relevant social science theories, in a disciplined and cumulative manner, to support decision making at the strategic and operational levels, and the creation of a large body of test cases against which integrated social science theories can be evaluated. In this way Large-Scale Asymmetric Systems will provide military leaders with the capability to realistically monitor, assess, and forecast in near-real time how global events and U.S. actions are affecting the behaviors of leaders, groups, and institutions in religiously, ethnically, and culturally diverse societies around the world. *FY 2011 Base Plans:* - Create learning models for dynamic cyber-physical-human networks that include foreign political, military, and popular leaders. - Demonstrate the feasibility of acquiring and maintaining cyber-physical-human dynamics data in near-real-time and of extracting reliable indications and warning. - Assess the potential of human, social, cultural, and behavioral theories to explain and predict the behaviors of foreign leaders and organizations. - Develop techniques for inferring a leader's intentions and actions based upon past behavior and statements and the socio-cultural environment.					
Accomplishments/Planned Programs Subtotals	0.000	0.000	44.682	0.000	44.682

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602305E: *MACHINE INTELLIGENCE*

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602383E: *BIOLOGICAL WARFARE DEFENSE*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	163.993	40.418	32.692	0.000	32.692	30.250	30.222	30.682	30.651	Continuing	Continuing
BW-01: *BIOLOGICAL WARFARE DEFENSE*	163.993	40.418	32.692	0.000	32.692	30.250	30.222	30.682	30.651	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) DARPA's Biological Warfare Defense project is budgeted in the Applied Research Budget Activity because its focus is on the underlying technologies associated with pathogen detection, prevention, treatment and remediation. This project funds programs supporting revolutionary new approaches to biological warfare (BW) defense and is synergistic with efforts of other Government organizations.

(U) Efforts to counter the BW threat include countermeasures to stop pathophysiologic consequences of biological or chemical attack, host immune response enhancers, medical diagnostics for the most virulent pathogens and their molecular mechanisms, tactical and strategic biological and chemical sensors, advanced decontamination and neutralization techniques, and integrated defensive systems. This program also includes development of a unique set of platform technologies that will dramatically decrease the timeline from military threat detection to countermeasure availability.

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	56.139	40.587	0.000	0.000	0.000
Current President's Budget	163.993	40.418	32.692	0.000	32.692
Total Adjustments	107.854	-0.169	32.692	0.000	32.692
• Congressional General Reductions		-0.169			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	-0.007	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	109.438	0.000			
• SBIR/STTR Transfer	-1.577	0.000			
• TotalOtherAdjustments	0.000	0.000	32.692	0.000	32.692

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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Change Summary Explanation

FY 2009

Increase reflects the reprogramming of funds for the H1N1 vaccine development offset by Section 8042 rescission of the FY 2010 Appropriations Act, the SBIR/STTR transfer and internal below threshold reprogramming.

FY 2010

Decrease reflects the Section 8097 Economic Adjustment.

FY 2011

Not Applicable

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Unconventional Therapeutics	116.486	13.338	12.000	0.000	12.000
(U) This thrust is developing unique and unconventional approaches to ensure that soldiers are protected against a wide variety of naturally occurring, indigenous or engineered threats. Past successes in this effort have come from developing therapeutics that are designed to work against broad classes of pathogens. Work in this area has also uncovered new approaches to therapeutics that, rather than attacking specific pathogens, enhance innate human immune mechanisms against broad classes of pathogens. Integral to these efforts is the development of methods that rapidly identify a broad spectrum of pathogens. Not only will these approaches be more effective against known pathogens, they also promise to offer substantial protection against unknown pathogens including engineered and emerging pathogens from third-world environments. (U) A current emphasis is on the discovery and development of technologies that will allow a rapid response (within weeks) to unanticipated threats, whether they are naturally encountered emerging diseases or agents from intentional attack. This thrust has a goal of radically transforming the protein design process by researching and developing new mathematical and biochemical approaches to the in silico design of proteins with specific functions. This significantly decreases the time needed and increases the probability of success for biological warfare vaccine development. An additional focus					

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
is the development of entirely new technologies that will allow the rapid, cost-effective manufacture of complex therapeutic proteins such as monoclonal antibodies and vaccine antigens; these technologies will reduce the time for biologics manufacture from years (or even decades) to only weeks. Leveraging these current and previously proven technologies, such as the Modular IMmune in Vitro Construct (MIMIC) artificial human immune system device, a complementary rapid response to the H1N1 pandemic is being accelerated. This includes identifying the symptoms and progression, predicting and diagnosing exposed individuals, developing a safe and effective treatment, and demonstrating technologies for mass-producing low cost vaccines. *FY 2009 Accomplishments:* - Expressed two DARPA-specified challenges to demonstrate flexibility of platform; one of which is in accordance with Food and Drug Administration (FDA) current good manufacturing processes (cGMP). - Demonstrated plant platform capability to produce millions of doses of DARPA-specified vaccines in twelve weeks with improved biochemistry metrics. - Demonstrated improved vaccine biochemistry metrics which include: protein solubility (greater than ninety-nine percent), fragmentation (less than 0.1 percent) and folding (greater than 99.9 percent). - Demonstrated reduced vaccine prototype production costs of less than one dollar per dose and/or monoclonal production of less than ten dollars per dose. - Determined common synthesis pathways for a set of pharmaceuticals frequently used and relevant to combat support hospital and far-forward care. - Researched controlled environment to monitor pathogen evolution in response to host specific interactions including vaccination. - Began developing a geometric, dynamic model to capture transportation flow and person-to-person interactions on local and global scales for informing potential upcoming pandemic hot spots. - Began overlaying sequencing and bio-informatics on the geometric model to capture biological dynamics, transmission, and viral evolution to identify virus mutation/reassortment possibilities that may require new vaccine countermeasures.					

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Began developing pre-symptomatic biomarker model predictive of H1N1 disease progression in individuals. - Began validating pre-symptomatic biomarker models to high probabilities of detection and low probabilities of false alarm early on after contact with a pathogen. - Sequenced early H1N1 virus and introduced it into plant-based vaccine technology which resulted in protein expression within 21 days. - Expanded plant-based vaccine prototype manufacturing capacity to meet target capability of 10 million doses/month at a Current Good Manufacturing Practices (cGMP) facility. - Evaluated national H1N1 vaccine candidate prior to an FDA clinical trial using DARPA's Rapid Vaccine Assessment an in vitro artificial human immune system. - Demonstrated cross protection of (H1N1) vaccine against emerging H1N1 mutations. - Prepared pre-investigational new drug (pre-IND) package for submission to the FDA. *FY 2010 Plans:* - Complete demonstration of 100-fold increase in vaccine manufacturing rate for other non-egg-based platforms to show a manufacturing rate greater than or equal to 100 doses per liter times number of weeks. - Demonstrate dose efficacy for other non-egg-based vaccines using animal models and DARPA's Rapid Vaccine Assessment, an in vitro artificial immune system. - Document vaccine contaminants, system development, and quality control to facilitate pre-investigational new drug meetings with FDA. - Identify means to prevent initial infection and secondary transmission of any contagious agent from primary to secondary contact. - Develop approaches for slowing disease progression and sustain survival from highly lethal infections until either immunity is achieved or treatment is administered. - Develop techniques to provide temporary protection against a pathogen in which the host has no immunity against.					

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop strategies that accelerate acquisition of effective persistent immunity before death from a lethal pathogen. *FY 2011 Base Plans:* - Develop innovative approaches to counter any known, unknown, naturally occurring or engineered pathogen. - Demonstrate that various technologies can increase the median lethal dose (LD50) of a given pathogen by 100-fold compared to the untreated control LD50 in order to prevent infection. - Demonstrate a 4-fold increase in survival time after a lethal dose (LD95) challenge of a given pathogen due to administered technology. - Demonstrate 95% survival against a first LD95 challenge of a given pathogen using a therapy developed within 7 days of receipt of a blinded pathogen, and deteriorating survival against subsequent challenge(s) with the initial LD95. - Demonstrate 95% survival after three LD95 challenges of a given pathogen spaced 1 week apart = 7 days post countermeasure. - Identify and confirm via animal studies one or more novel molecular approaches that disarms pathogens, thus allowing them to be eliminated by the host immune defenses.					
External Protection (U) This program is developing and demonstrating a variety of technologies to protect soldiers from the hazards of chemical, biological and radiological attack, and other hazards such as large unstable weapons stores. The program will focus on the integrated thermal model of combatant in operational conditions and address the heat transfer coupling for better evaporative cooling. *FY 2009 Accomplishments:* - Demonstrated biocidal efficacy of active textile cells on animal remains. - Field tested the optimized self-decontaminating polyurethane based chemical agent resistant coating (CARC) on military vehicles at Dugway Proving Grounds using biological warfare simulants.	4.848	2.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop an integrated thermal model of a combatant under operational conditions including bioheat generation, internal convective (blood) and conductive (tissue) heat transfer, and coupling to ambient heat baths by radiation, conduction, evaporation, and convection. - Investigate fabrics and garment architectures that allow tuning of evaporative and convective heat transfer from the body behind a chemically impermeable external shell.					
Advanced Diagnostics (U) In the early stages, many illnesses caused by biological warfare (BW) agents are either asymptomatic, or else have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The Advanced Diagnostics program developed the capability to detect the presence of infection by biological threat agents, differentiate them from other pathogens (including those of non-BW origin), and identify the pathogen even in the absence of recognizable clinical signs and symptoms (i.e., while the pathogen numbers are still low). Novel approaches including the use of breath and advanced mathematical analysis were also examined. *FY 2009 Accomplishments:* - Refined predictive model of impending illness to increase the probability of detection and reduce probability of false alarms. - Confirmed predictive model of impending illness accuracy in large sample-size, warfighter relevant populations. - Evaluated potential diagnostic platforms for rapid identification of host molecular markers, which indicate viral infection prior to the onset of symptoms. - Developed proof of concept biosensors based on "best fit" of diagnostic platforms, predictive models, and host molecular marker studies. - Evaluated radiation technologies at the Armed Forces Radiobiology Research Institute (AFRRI) in a live fire test to identify best biodosimeters.	8.593	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Hyperadsorptive Atmospheric Sampling Technology (HAST)*	28.974	25.080	20.692	0.000	20.692

*Formerly Sensors.

(U) The Hyperadsorptive Atmospheric Sampling Technology (HAST) program will enable exhaustive, accurate, and economical collection of atmospheric trace constituents to support chemical mapping of urban and military environments. The system will demonstrate materials, packaging, and extraction technologies that sample atmospheric impurities whose concentrations range from 10 parts per trillion to 100 parts per million by volume from 100 liter-atmospheres of gas in less than five minutes. New systems to provide rapid, comprehensive, and quantitative trace gas analysis without preconceived lists or libraries of target chemicals will also be developed. The analysis systems will integrate sophisticated separation and spectroscopic techniques with advanced quantum chemistry algorithms to enable library-free identification and ranking (by concentration) of all components present in complex gas mixtures. This capability will revolutionize our understanding of the environment through chemical mapping and reconnaissance. Reproducible analysis of atmospheric samples using sophisticated analytical technology will yield maps of baseline conditions, natural variability, and permit detections of nefarious anomalies involving production, movement, and storage of weapons.

FY 2009 Accomplishments:
- Developed sampling technology based on carbide derived carbon, cyclodextrins, and metal-organic framework complexes.
- Confirmed through independent testing that HAST capsules satisfied program requirements for 85% fidelity (ability to collect arbitrary compounds) and 85% accuracy (ability to correctly rank relative concentrations).
- Extended dynamic range of time of flight mass spectrometry instruments.

FY 2010 Plans:
- Engineer portable prototype systems for autonomous collection on mobile and stationary platforms.
- Integrate sample labeling with meteorological data, time, and geographic coordinates.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Extend accuracy and fidelity of HAST capsules to 95%. - Test prototype architecture using calibrated gas mixtures. - Engineer systems for 100 samples per shift (125 samples per hour). *FY 2011 Base Plans:* - Deliver and field test functional sampling technology prototypes for autonomous vehicle-borne operation. - Demonstrate adsorbent manufacturing technology and economical (<$0.10/sample) collection. - Integrate sampling technologies with laboratory analytical systems. - Build and demonstrate prototype analytical systems that analyze 3,000 mixtures per day with up to 300 components ranging in concentration from 50 micromoles to 50 picomoles. - Design and validate a system to analyze up to 300,000 samples per day for less than $0.10 per sample that fits in a standard shipping container. - Field test fully integrated system for chemical map generation. - Identify chemical composition of unknown materials for which library spectra are unavailable.					
Threat Agent Cloud Tactical Intercept Countermeasure (TACTIC) (U) The Threat Agent Cloud Tactical Intercept Countermeasure (TACTIC) program explored methodologies to proactively defend against biological warfare agent (BWA) and chemical warfare agent (CWA) attacks on fixed sites and mobile troops on the battlefield. The approach was to develop a standoff (kilometers), integrated system for rapid identification and neutralization of BWA/CWA threat clouds. As part of the overall system design, the program developed modeling and simulation (M&S) capabilities to model threat agent plume generation, transport and dispersion, as well as threat agent and counteragent interactions such as agglomeration/coagulation, and adsorption/absorption. *FY 2009 Accomplishments:* - Completed preliminary design reviews (PDRs) for integrated systems development. - Completed independent Government testing of a neutralization solution.	2.228	0.000	0.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	PE 0602383E: *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Began post-PDR software development effort to model BWA/CWA threat cloud transport and dispersion and interaction of threat agent and counteragent aerosol/vapor clouds on the battlefield and in urban areas. - Continued development of high-fidelity model to accurately simulate threat agent transport and dispersion, threat agent and counteragent interactions, and the effectiveness and limitations of various applied countermeasures under a variety of atmospheric conditions. - Delivered the M&S software and associated documentation to the Government. - Transitioned the M&S software capability to the Defense Threat Reduction Agency (DTRA).					
Mission-Adaptable Chemical Sensors (MACS) (U) At present, chemical sensors are unable to combine sensitivity (parts-per-trillion (ppt)) and selectivity (unambiguous identification of molecular species) with low false alarm rate. This effort has investigated the nature of the atmospheric background “clutter” at the parts per billion (ppb) level and below to enable the identification of target signatures at highest sensitivity. The program focused on reduction of size and simplicity of function to achieve portability and simultaneous detection of a large number (hundreds) of species. The result of the program is a portable chemical sensor that achieved all the above goals. It is unique in that it achieves the highest sensitivity (ppt) with highest selectivity (virtually no false alarms in numerous tests of sample mixed gases). *FY 2009 Accomplishments:* - Identified users and particularized the MACS sensor for their objectives. - Extended the spectral reference library of analytes to hundreds to suit the different applications. - Automated the sensor to identify the chemical analytes within a sample using computer lookup. - Reduced sample analysis time to less than one minute.	2.864	0.000	0.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	163.993	40.418	32.692	0.000	32.692

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	316.166	248.683	224.378	0.000	224.378	260.518	304.072	309.564	313.391	Continuing	Continuing
TT-03: *NAVAL WARFARE TECHNOLOGY*	60.373	32.654	32.118	0.000	32.118	52.349	83.525	80.306	80.255	Continuing	Continuing
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	40.732	29.202	18.411	0.000	18.411	25.303	28.236	25.210	25.185	Continuing	Continuing
TT-06: *ADVANCED TACTICAL TECHNOLOGY*	122.827	81.739	69.018	0.000	69.018	75.920	48.862	69.513	69.443	Continuing	Continuing
TT-07: *AERONAUTICS TECHNOLOGY*	31.316	31.956	42.334	0.000	42.334	70.431	99.504	90.214	94.245	Continuing	Continuing
TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*	60.918	73.132	62.497	0.000	62.497	36.515	43.945	44.321	44.263	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

(U) The Naval Warfare Technology project develops advanced enabling technologies for a broad range of naval requirements. Technologies under development will increase survivability and operational effectiveness of small and medium surface vessels in rough seas and demonstrate advanced technologies for hypersonic flight. New areas to be investigated include ship self defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations and predictive tools for small craft hydrodynamic design.

(U) The Advanced Land Systems project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire.

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

(U) The Aeronautics Technology project explores technologies to reduce costs associated with advanced aeronautical systems and provide revolutionary new capabilities for current and projected military mission requirements. This project funds development of micro adaptive flow control technologies; small-scale propulsion system concepts; and a high-strength, low structural weight airlift vehicle designed to control its buoyant lift independently of off-board ballast. New areas to be investigated are reusable hypersonic vehicles; novel helicopter blade designs that reduce acoustic signature; small, low cost high endurance UAV's capable of destroying most enemy UAV's; and short distance take-off and landing of fixed wing aircraft.

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

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	352.924	276.075	0.000	0.000	0.000
Current President's Budget	316.166	248.683	224.378	0.000	224.378
Total Adjustments	-36.758	-27.392	224.378	0.000	224.378
• Congressional General Reductions		-1.042			
• Congressional Directed Reductions		-55.950			
• Congressional Rescissions	-10.023	0.000			
• Congressional Adds		9.600			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-16.820	0.000			
• SBIR/STTR Transfer	-9.915	0.000			
• Congressional Restoration for New Starts	0.000	20.000	0.000	0.000	0.000
• TotalOtherAdjustments	0.000	0.000	224.378	0.000	224.378

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*

Congressional Add Details ($ in Millions, and Includes General Reductions)	**FY 2009**	**FY 2010**
Project: TT-03: *NAVAL WARFARE TECHNOLOGY*		
Congressional Add: *Center of Excellence for Research in Ocean Sciences (CEROS)*	10.000	8.000
Congressional Add: *SeaCatcher Unmanned Aircraft Launch and Recovery System*	1.600	1.600
Congressional Add Subtotals for Project: TT-03	11.600	9.600
Project: TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*		
Congressional Add: *Optical Sensor System*	0.800	0.000
Congressional Add Subtotals for Project: TT-04	0.800	0.000
Congressional Add Totals for all Projects	12.400	9.600

Change Summary Explanation

FY 2009

Decrease reflects the Section 8042 rescission of FY 2010 Appropriation Act, Omnibus Reprogramming action for the H1N1 vaccine development, SBIR/STTR transfer and internal below threshold reprogramming.

FY 2010

Decrease reflects the reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts offset by congressional adds (as identified above) and FY 2010 Congressional Restoration for New Starts.

FY 2011

Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TT-03: *NAVAL WARFARE TECHNOLOGY*	60.373	32.654	32.118	0.000	32.118	52.349	83.525	80.306	80.255	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling and novel technologies include concepts for expanding the envelope of operational naval capabilities such as drag reduction, ship stability, hypersonic missiles, logistically friendly distributed lighting systems, ship self defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations, high speed underwater vessels, improved techniques for underwater object detection and discrimination, long endurance unmanned surface vehicles, and high bandwidth communications.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Super-Fast Submerged Transport (U) The Super-Fast Submerged Transport program (Underwater Express) will explore the application of supercavitation technology to underwater vehicles, enabling high speed transport of personnel and/or supplies. The inherent advantages of traveling underwater are: the ability to transit clandestinely, no radar or visible signature, and avoidance of rough sea conditions that may limit or deny mission execution. Supercavitation places the vehicle inside a cavity where vapor replaces the water, and drag due to fluid viscosity is reduced by orders of magnitude, thus reducing the power requirement dramatically. This program will use modeling, simulation, experiments and testing to develop the understanding of the physical phenomena associated with supercavitation and the application to underwater vehicles. Innovative failsafe controls will be required for stability and maneuverability at speed. The program will culminate in an at-sea demonstration of an unmanned vehicle capable of fully wetted to supercavitating operations and autonomous maneuvering. *FY 2009 Accomplishments:* - Developed vehicle control system and algorithms.	16.638	13.554	2.411	0.000	2.411

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Conducted extensive simulation testing with increasing vehicle and environmental fidelity. - Conducted modeling, simulations, and experiments to refine understanding of cavity and vehicle control and stability. - Continued development of vehicle design including propulsion system design and integration, and design, fabrication and testing of a scaled prototype vehicle. *FY 2010 Plans:* - Complete design, fabrication and component testing of a scaled vehicle. - Conduct initial at-sea testing of a scaled vehicle. - Analyze vehicle performance for speed, power and stability. - Complete development of vehicle control system. - Modify vehicle systems for at-sea testing series based on testing results. *FY 2011 Base Plans:* - Complete at-sea testing of a scaled vehicle.					
Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV) *Formerly Extremely Long Endurance Surface Vessel (ELEUSV) (U) The Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV) program will develop an unmanned X-ship design based on the premise that a human is never intended to step aboard at any point in the operations cycle. In doing so, an unexplored design space emerges without constraint on structure, stability, or crew support, in contrast to their significant impacts in conventional ship design. ACTUV will be an independently deployed unmanned naval vessel under spares remote supervisory control. This, coupled with a novel suite of sensors capable of robustly tracking quiet modern diesel electric submarines, will demonstrate a game changing ASW operational capability. Key technical areas include sensor fusion to integrate diverse sensors applied in non-traditional ways,	2.400	3.500	6.500	0.000	6.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
system autonomy to execute independent deployment under sparse remote supervisory control, and system integration due to the complexity and unique configuration of the ACTUV platform. *FY 2009 Accomplishments:* - Conducted analysis of unmanned naval vessel concepts and operational employment. - Identified core technologies required to enable unique large scale unmanned naval vessel capabilities. - Developed exploratory system concept designs. - Conducted preliminary operations effectiveness analysis and developed concept of operations to take advantage of unique system characteristics. *FY 2010 Plans:* - Conduct mission-focused integrated system concept development. - Make critical enabling technology assessments and preliminary selections. - Conduct producibility and manufacturing sourcing analysis. - Generate preliminary system performance specifications. - Complete user assessment of strategic and operational value. - Expand concept to underwater applications. *FY 2011 Base Plans:* - Integrate best of breed system performance specifications from competing system concepts to underpin detail design process. - Conduct system preliminary design. - Conduct critical subsystem technology demonstration planning and risk reduction testing. - Demonstrate enabling manufacturing processes and validate production cost estimates. - Initiate high fidelity operational effectiveness analysis and concept of operations development. - Commence development of promising technologies for extension to underwater applications.					
Submersible Aircraft	0.000	3.000	8.000	0.000	8.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) This program will combine the speed and range of an airborne platform with the stealth of an underwater vehicle by developing a vessel that can both fly and submerge. The program will exploit lightweight materials, unique dynamic structures and advanced propulsion systems to overcome the technical barriers to achieving this capability. If successful, the program will enable insertion and extraction of special operations and expeditionary forces at greater ranges, and higher speeds in locations not previously accessible with minimal direct support from additional military assets. The program goals are to demonstrate a vessel capable of multimodal operations (airborne, surface, and submerged) and that can easily transition between these modes. *FY 2010 Plans:* - Conduct concept design studies and perform feasibility analysis in order to quantify extent of possible operational envelope. - Identify key technology limitations and performance objectives that need to be overcome in order to achieve concept design. *FY 2011 Base Plans:* - Complete developmental activities including modeling and experiments, demonstrating technologies, and approaches that can overcome the identified performance objectives. - Complete objective system design based on the results of developmental activities, providing an accurate projection of the systems operational envelope.					
Non-traditional Active Sonar (U) The goal of the Non-traditional Active Sonar program is to develop alternative solutions for anti-submarine warfare active sonar. Given the trend of submarine quieting, passive sonar is of diminishing value to the Navy for large area searches. The existing alternatives are high power active sonar systems which are overt and difficult to use in peace time given concerns for the environment. The program will investigate new approaches which exploit special acoustic phenomena through advanced	0.000	2.000	6.000	0.000	6.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
active sonar signal processing to counter the need for high peak power sonar. Emphasis is on data-driven algorithms applicable across existing Navy towed and bottom arrays. *FY 2010 Plans:* - Develop initial processing algorithms for use with the initial data set. - Exercise the algorithms with surrogate or simulated data. - Conduct controlled data collection with surrogate sources and targets. - Develop and assess algorithms using collected data. *FY 2011 Base Plans:* - Iterate on algorithm designs to assess detection capability (e.g., range) and extrapolate performance to other environments and concepts of operations. - Conduct at-sea demonstration with real targets to assess performance under realistic conditions and to justify relevant systems concepts.					
Very High Speed Vessel (VHSV) (U) The Very High Speed Vessel (VHSV) program will explore the development of a small tactical surface vessel capable of protecting high value naval vessels in contested littoral environments. The VHSV will exhibit tactical mobility and mission endurance well beyond that of any current or proposed littoral warfare platform. The vessel will be able to operate as either a manned or unmanned naval combat vessel and will be optimized to defend against irregular naval warfare threats such as Fast Inshore Attack Crafts (FIACs), high speed swarming combatant boats, and conventional diesel submarines operating in shallow coastal waters. The VHSV will leverage emerging developments in reconfigurable hull forms, fluid drag reduction, hybrid naval propulsion design, and dynamic control in fully cavitated flow to develop a vessel with significantly superior maximum speed and seakeeping in elevated sea states.	0.000	0.000	4.207	0.000	4.207

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete military and tactical utility study and establish vessel's development metrics. - Conduct major system trade off analyses. - Initiate concept design and risk reduction analysis and testing.					
Caiman (U) The Caiman program will develop a prototype amphibious robotic vehicle which will navigate tropical rivers autonomously for long range/long duration missions (~100 kilometers and ~7+ days) while gathering intelligence. Navigating tropical rivers requires traversing long stretches of sandbars, very shallow water and avoiding small to large obstacles. It also demands new advances in perception, autonomy and locomotion to enable the system to make progress in cluttered, shallow waters, including occasionally exiting the water, traversing ground such as sandbars, and then reentering. The Caiman mission is targeted for the interface between water and land, which will result in the vehicle being able to access riverine and swamp areas which are inaccessible. *FY 2011 Base Plans:* - Develop, analyze and assess preliminary designs to achieve a system capable of a hundred kilometers of travel over a 7 day mission. - Simulate water to land to water transitions to validate design. - Build subsystems that prove design validity.	0.000	0.000	5.000	0.000	5.000
Hypersonics Flight Demonstration (HyFly) (U) The Hypersonics Flight Demonstration (HyFly) program will develop and demonstrate advanced technologies for hypersonic flight. The ultimate goal of the program is to demonstrate vehicle performance that could lead to an operational tactical surface launched missile range of 600 nautical miles. Specifically, the program will demonstrate an F-15 launched missile configuration with a range of 400 nautical miles, a maximum sustainable cruise speed in excess of Mach 6, and the ability	2.200	1.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
to accurately terminate the missile on a GPS guided impact target. Technical challenges include the scramjet propulsion system, lightweight, high-temperature materials for both aerodynamic and propulsion structures, and guidance and control in the hypersonic flight regime. Based on the results of the first two test flights, subsystem components will be modified and a third flight test has been added to the program development schedule. *FY 2009 Accomplishments:* - Conducted testing of modified subsystems. - Conducted fuel system and nose assembly shock and vibration testing. - Fabricated major engine components. - Assembled flight vehicle, perform ground testing and check-out. *FY 2010 Plans:* - Continue assembly of flight vehicle and perform ground testing and subsystem check outs. - Complete final testing activities.					
Long Range Anti-Ship Missile (LRASM) (U) The Long Range Anti-Ship Missile (LRASM) program is investing in advanced component and integrated system technologies capable of providing a dramatic leap ahead in U.S. surface warfare capability, focusing on organic wide area target searches and discrimination in a network denied environment, innovative terminal survivability in the face of advanced defensive systems, and high assurance target lethality approaches. Specific technology development areas include robust precision guidance, navigation and control with GPS denial, multi-modal sensors for high probability target identification in dense shipping environments, and precision aimpoint targeting for maximum lethality. Component technologies will be developed, demonstrated, and integrated into a prototype demonstration weapon system. The program will result in high fidelity demonstration to support military utility assessment. This program is funded from PE 0603286E, Project AIR-01, Advanced Aerospace Systems in FY 2010.	27.535	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Conducted threat modeling. - Conducted system performance operations analysis. - Conducted analytical trade studies to select seeker and datalink subsystems. - Conducted subsystem preliminary designs. - Initiated integrated system preliminary designs. - Commenced risk reduction testing of critical seeker, propulsion, and aerodynamic components.					
Accomplishments/Planned Programs Subtotals	48.773	23.054	32.118	0.000	32.118

	FY 2009	FY 2010
Congressional Add: Center of Excellence for Research in Ocean Sciences (CEROS) *FY 2009 Accomplishments:* - Completed projects started in FY 2008. - Selected projects for FY 2009 funding. - Contracted for selected projects and monitored progress of ocean related technologies of high interest to the DoD. *FY 2010 Plans:* - Select projects and monitor progress of ocean related technologies of high interest to the DoD.	10.000	8.000
Congressional Add: SeaCatcher Unmanned Aircraft Launch and Recovery System *FY 2009 Accomplishments:* - Explored launch and recovery system concepts.	1.600	1.600

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
FY 2010 Plans: - Continue to explore launch and recovery system concepts.		
Congressional Adds Subtotals	11.600	9.600

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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency			**DATE:** February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	40.732	29.202	18.411	0.000	18.411	25.303	28.236	25.210	25.185	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Recognize Improvised Explosive Devices and Report (RIEDAR) (U) The goal of the Recognize Improvised Explosive Devices and Report (RIEDAR) program is to develop and demonstrate a capability for stand-off detection of various devices. *FY 2009 Accomplishments:* - Demonstrated operation of compact, tunable lasers from deep ultraviolet (UV) to near infrared (NIR). *FY 2010 Plans:* - Investigate designs for sub-system consisting of optical detector and compact laser for detection of explosives.	1.463	1.000	0.000	0.000	0.000
Magneto Hydrodynamic Explosive Munition (MAHEM) (U) The Magneto Hydrodynamic Explosive Munition (MAHEM) program will demonstrate compressed magnetic flux generator (CMFG)-driven magneto hydrodynamically formed metal jets and self-forging penetrators (SFP) with significantly improved performance over explosively formed jets and fragments. Explosively formed jets (EFJ) and SFP are used for precision strike against targets such as armored	2.705	1.616	1.210	0.000	1.210

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
vehicles and reinforced structures. Current technology uses chemical explosive energy to form the jets and fragments. This is highly inefficient and requires precise machining of the metal liners from which the fragments and jets are formed. Generating multiple jets or fragments from a single explosive is difficult and the timing of the multiple jets or fragments cannot be controlled. MAHEM offers the potential for higher efficiency, greater control, the ability to generate and accurately time multiple jets and fragments from a single charge, and the potential for aimable, multiple warheads with a much higher EFJ velocity, hence increased lethality precision, than conventional EFJ/SFP. MAHEM could be packaged into a missile, projectile or other platform, and delivered close to target for final engagement. This could provide the warfighter with a means to address stressing missions such as: lightweight active self-protection for vehicles (potential defeat mechanism for a kinetic energy round), counter armor (passive, reactive, and active), mine countermeasures, and anti-ship cruise missile final layer of defense. *FY 2009 Accomplishments:* - Successfully tested a static brassboard prototype of a self-contained MAHEM munition to demonstrate the ability to package a MAHEM device into a shoulder-launched munition form factor. *FY 2010 Plans:* - Using theoretical models, design flux compression generator (FCG) components in preparation for fabrication and testing of the armature and stator configuration with static and dynamic loads. - Perform testing of FCG components. - Design, model, and fabricate shaped charge liners and magnetically formed penetrators (MFPs) that will provide maximum penetration against hardened targets of interest. - Test shaped charge liners and MFPs. *FY 2011 Base Plans:* - Design and model dual liners composed of the main shaped charge liner and an MFP liner wherein both are powered by the same FCG.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Lightweight Ceramic Armor (LCA)	4.529	2.000	0.000	0.000	0.000

(U) The Lightweight Ceramic Armor (LCA) program leverages recent breakthroughs in novel ceramic fabrication processes developed in the Materials Processing Technology project to drive a dramatic performance shift in the trade-off between weight and ballistic projectile protection of body armor. Currently fielded Boron Carbide body armor is heavy and limited in the diversity of shapes that may be molded. Its weight and bulk limit a soldier's agility and mobility, and its cost prohibits consideration of using it to protect vehicles. Recent breakthroughs in ceramics processing technology offers the opportunity for cost effective fabrication of molded shapes, the retention of nanostructured grains for significantly higher energy dissipation, a fifty percent reduction in weight for equal ballistic protection, and similar reduction in cost. The focus areas of the program are: the optimization of the material composition and nanostructure for maximum protection per unit weight and cost, and scale up of the fabrication technology to body armor size scale articles. The program will additionally investigate the potential for the development of dramatically improved ballistic armored headgear along these same lines.

FY 2009 Accomplishments:
- Optimized integrated backing materials - ceramic armor materials systems for minimum weight at Enhanced Small Arms Protective Inserts ESAPI ballistic performance.
- Evaluated the characteristics of an optimized LCA system optimized for minimum weight at ESAPI ballistic performance.

FY 2010 Plans:
- Validate an initial fifteen percent reduction in weight for equal performance compared to currently fielded ESAPI armor inserts.
- Investigate the potential for significantly improved ballistic characteristics of meta-structured ceramic systems incorporating multiple materials layers in a monolithic plate.
- Develop and evaluate initial concepts for ballistic headgear incorporating the LCA materials.

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate key manufacturing steps at pilot scale throughput with consistent and reliable yielded ceramic part performance.					
Crosshairs (U) The Crosshairs program seeks to develop a vehicle mounted threat detection and countermeasure system that will detect, locate, and engage enemy shooters against a variety of threats to include bullets, Rocket Propelled Grenades (RPGs), Anti-Tank Guided Missiles (ATGMs), and direct fired mortars, both stationary and on the move. Threat identification and localization will be accomplished in sufficient time to enable both automatic and man-in-the-loop responses. Phase I of the program focused on initial development and testing of the Crosshairs sensor system. Phase IA culminated with a static live fire test to determine the most effective candidate sensor system. During Phase IB, enhancements were made to the sensor system for on the move performance, and on the move testing against multiple threats was conducted. DARPA and the U.S. Army Rapid Equipping Force (REF) entered into an MOA for Phase IIA. Phase IIA consisted of a moving demonstration of the hardened, packaged, and enhanced Phase I sensor system on two networked HMMWVs (Humvee), integration with candidate response systems, and testing and evaluation of the complete systems in relevant environments. The program is currently in Phase IIB. During this phase, the Crosshairs sensor system is being integrated with the Iron Curtain Active Protection System (IC-APS) on four up-armored vehicles. At the end of Phase IIB, the Crosshairs systems will be ready for field testing. (U) The Concept of Operations is to provide a military vehicle with an affordable vehicle mounted detection and response system that operates both stationary and on the move for light tactical vehicles. Bullets will be detected and localized using the DARPA-developed Boomerang acoustic gunfire detection system. Radar detection of all other threats will be made using the CrossCue radar. Protection against incoming RPGs will be provided by the IC-APS. The CrossCue radar is a dual mode, continuous wave, and pulsed Doppler radar, which will be used to determine range, velocity, and angle of bearing of the incoming threat. IC-APS uses the CrossCue Radar to alert the optical break screen of incoming RPGs. The optical break screen characterizes the threat and activates the cutting	9.211	6.000	3.900	0.000	3.900

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
charge to engage the warhead and cut the fuse. Technology challenges include: improving target classifier, reducing navigational drift, reducing effects of acoustic noise, improving estimates for point of closest approach and velocity, and integration of the IC-APS and CrossCue Radar. (U) DARPA is working with the Army Rapid Equipping Force (REF) and the Project Manager Mine Resistant Ambush Protected Vehicles (PM-MRAP) to validate the capabilities and initiate transition to combat forces in the 2010/2011 time frame. *FY 2009 Accomplishments:* - Demonstrated final hardened CrossCue system capabilities. - Performed on the move tests with hardened system against simultaneous RPGs. - Demonstrated ability to slew, acquire, and track a specific target. - Demonstrated networking capability between two Crosshairs sensor systems. *FY 2010 Plans:* - Complete integration of the APS and CrossCue system. - Validate system performance and field-worthiness through testing by the Army Test and Evaluation Command (ATEC). *FY 2011 Base Plans:* - Demonstrate final integrated system capability including active protection in live fire tests. - Transition Crosshairs technology to the military.					
Rocket Propelled Grenade (RPG) Nets (U) The goal of the Rocket Propelled Grenade (RPG) Nets program is to develop a near-term counter RPG net system that has performance at least equivalent to bar or slat armor but that is lighter and easier to deploy; and a mid-term net-based system with active elements that has greatly improved performance. Development of these systems will be supported by modeling to enhance understanding	5.079	3.306	0.900	0.000	0.900

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
of the net interactions and with extensive live fire testing against RPGs. Successful candidates will be installed on vehicles for evaluation in an operational context. DARPA is working with the USMC Program Manager for Motor Transport (PMMT) to develop, test and transition this capability to combat forces. *FY 2009 Accomplishments:* - Developed near-term net concepts and performed initial live fire evaluation. - Conducted all-up live fire evaluation on competing net concepts. - Determined vehicle type for net application and joint path forward with USMC. *FY 2010 Plans:* - Install near-term net systems on military vehicles and perform initial user evaluation. - Commence evaluation of near-term net system and initiate transition. *FY 2011 Base Plans:* - Complete evaluation of near-term net system and initiate transition.					
Helicopter ALert and Threat Termination (HALTT) (U) The Helicopter ALert and Threat Termination (HALTT) program will provide Army and Navy/Marine helicopters with a way to detect small arms and provide shooter location to improve their ability to respond. System effectiveness with emphasis on low false alarm rates is critical. The program goal is to successfully demonstrate protection of helicopters by automatic threat detection of small arms with an "o'clock" accuracy in azimuth as well as elevation and range to shooter. *FY 2009 Accomplishments:* - Integrated the acoustic system on a UH-60 Blackhawk and validated system performance against live fire in all flight regimes. - Demonstrated light and heavy caliber shooter location determination and multi-shooter performance.	4.800	3.850	2.500	0.000	2.500

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Developed HALTT system preliminary design and system integration plan. - Began analysis of defeat mechanisms against RPGs. *FY 2010 Plans:* - Install prototype HALTT systems on platforms for CONOPS evaluations. - Demonstrate the HALTT prototype system in operational evaluation scenarios. - Enhance sensor design and platform interface. - Integrate the acoustic sensors on unmanned aircraft to determine true system accuracy. *FY 2011 Base Plans:* - Integrate and demonstrate acoustic system on multiple platforms. - Demonstrate a fully integrated HALTT system in operational scenarios.					
C-Sniper (U) Based on promising results obtained under the Crosshairs program, the C-Sniper effort will develop the capability to detect and neutralize enemy snipers before they can engage U.S. Forces. The program will lead to the delivery of a field testable prototype suitable for experimentation as an integrated part of the DARPA Crosshairs system. The C-Sniper system will identify threats before they can fire. The enemy snipers may be operating both with, and without, telescopic sights, and other optical systems in highly cluttered urban environments. The C-Sniper system will operate day and night from a static or moving military vehicle and will provide the operator with sufficient information to make a timely engagement decision. Once the decision is made, the C-Sniper will provide data and control to point and track the on-board weapon on the selected target. The final decision to fire the weapon will be left to the operator. *FY 2009 Accomplishments:* - Developed the key technologies (laser system, sensor head, and system processing designs). - Developed the interfaces of the sensor system to integrate with Crosshairs.	8.645	9.845	9.901	0.000	9.901

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Conducted systems integration and test on stationary vehicle. - Developed and incorporated system design enhancements required for a moving vehicle. *FY 2010 Plans:* - Develop, deliver and demonstrate the operation of C-Sniper on moving vehicles. - Demonstrate system capability to correctly detect optical systems in highly cluttered urban environment. - Integrate C-Sniper into Crosshairs and demonstrate full system capability. - Commence demonstration of a fully integrated system capable of combining C-Sniper and Crosshairs technologies. *FY 2011 Base Plans:* - Complete demonstration of fully integrated system capabilities. - Transition to the Army and Marine Corps.					
Rocket Propelled Grenade (RPG) Pre-launch Detection and Cueing (U) The Rocket Propelled Grenade (RPG) Pre-launch Detection and Cueing program will enable the development of an omni directional, visual, vehicle mounted surveillance system for threat detection using cognitive swarm recognition technology to rapidly detect and identify the locations of attackers with RPGs before they are launched. During the first phase of the program, a system will be demonstrated capable of 360 degree coverage and detection rates of greater than ninety-five percent. Minimizing false alarms and false positives will be key, as will be true day/night operation and the simultaneous identification of multiple threats. *FY 2009 Accomplishments:* - Investigated methods to develop and mature detection and classification algorithms.	1.500	1.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Analyze and document promising methods for detection and classification algorithms.					
Counter Improvised Explosives Laboratories (CIEL) (U) Improvised explosives (IEs) are one of the most popular weapons used by terrorist groups. Over the past twenty years, IEs have become very common due to their easy preparation and the high availability of raw materials. Efficient methods for detecting and neutralizing/desensitizing sensitive explosives labs in an urban environment will minimize interference with troop operations and minimize collateral damages. The goal of the Counter Improvised Explosives Laboratories (CIEL) program is to develop the infrastructure and methodology for novel chemo-sensors that would identify labs that are building IEs to a very high degree of specificity and reliability; and develop the infrastructure for tools for safe handling of improvised explosives and their mixtures. The CIEL program will also examine methods to improve current collection techniques used to detect sensitive explosives and their residues in an urban environment. The goal is to develop a detection system that is sufficiently selective and sensitive for collection of trace explosives; this system will be field-deployable and will provide clear and fast identification of the target explosive with minimal impact on troop operations. *FY 2009 Accomplishments:* - Developed prototype sensor kit with built-in validation techniques to reduce occurrence of false positive results. - Deployed prototype sensor kit for end-user feedback. - Tested neutralization/desensitization methods on “field-form” mixtures of explosives. - Evaluated design concept for multi-structured “smart” wipe. - Developed direct spectroscopic methodology for analysis of wipe and contaminate particles. - Developed prototypes of multi-scaled nano-fiber based “smart” wipe. *FY 2010 Plans:* - Assess field configuration of neutralization technology.	1.000	0.585	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate final prototype field kit for desensitization/decomposition on mixtures of explosives. - Demonstrate nanostructure based “smart” wipe. - Develop detection reagents for contaminant particles collected by "smart" wipe. - Develop and field test prototype “smart” wipe.					
Guided Projectiles (U) The Guided Projectiles program developed and demonstrated highly maneuverable gun-launched projectiles, and associated fire control and launch systems for employment against critical enemy infrastructure and point targets, such as command, control and communication nodes and radars. This program focused enabling technologies to give U.S. warfighters the ability to allow weapons platforms, such as mortars, to receive updated target information from other munitions or sense target changes on their own. (U) The program developed low-cost, non-imaging optical seeker/guidance technology exploiting technology development in the visible and infrared spectrum, designed to replace the current 60mm mortar fuse and improve firing precision. Additionally, research was conducted with explosives to improve the effectiveness of 60mm explosive rounds. The goal was to develop a 60mm projectile with the effectiveness of a 105mm high explosive projectile. Technology developed for the 60mm projectile was investigated for application to the 81mm and 120mm mortars to increase the accuracy and effectiveness of all fielded mortar rounds at a low cost. *FY 2009 Accomplishments:* - Designed integration plan for incorporating test seeker-guidance system on large caliber (81mm or 120mm) mortar rounds.	1.000	0.000	0.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	39.932	29.202	18.411	0.000	18.411

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Optical Sensor System *FY 2009 Accomplishments:* - Selected sensor and developed processing for defeat of explosively formed projectiles.	0.800	0.000
Congressional Adds Subtotals	0.800	0.000

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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TT-06: *ADVANCED TACTICAL TECHNOLOGY*	122.827	81.739	69.018	0.000	69.018	75.920	48.862	69.513	69.443	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
High Power Efficient and Reliable Laser Bars (HiPER) (U) The goal of the High Power Efficient and Reliable Laser Bars (HiPER) program is to develop linear bars of laser diodes that are more than seventy percent efficient in converting electrical power to optical output power. These laser diode bars will be used for supplying the optical pump power to ytterbium (Yb) and neodymium (Nd) solid state lasers operating near 1060 nanometers (nm). Such high efficiency laser pumps will lead to dramatic reductions in the size and weight of 100 kW class diode pumped solid state lasers based on reduced size and weight of not only the electrical power supply, but also reduced size and weight of the thermal management system. The goal of the HiPER program is also to retain high wall-plug efficiency of over seventy percent while ultimately producing compact laser diode bars with more than 250 W/bar-cm at lifetimes of greater than 100 hours.	2.240	4.872	9.800	0.000	9.800

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Demonstrated operation of 1cm laser diode bar at a power of 250 watts with a lifetime greater than 100 hours to allow an additional factor-of-2 reduction in diode pumped solid-state laser system size and weight. - Demonstrated novel, compact impingement cooling technology to increase laser diode bar cooling technology and enable 1000 W laser diode bars operating with 1.8mm pitch. *FY 2010 Plans:* - Determine operational status of Super High Efficiency Diode Sources (SHEDS) lasers operated at 120 Watts after the fault rate has saturated and the laser is switched from fault protected mode to a standard power supply. - Acquire commercial off-the-shelf (COTS) 860 nm wavelength, 2mm long cavity laser bars for test set development. *FY 2011 Base Plans:* - Perform data reduction and failure mode analysis. - Test laser bars for fault rate saturation and laser switching from fault protected mode to standard power supply. - Demonstrate reduced failure rate for laser bars.					
High Energy Liquid Laser Area Defense System (HELLADS) (U) The goal of the High Energy Liquid Laser Area Defense System (HELLADS) program is to develop a high-energy laser weapon system (150 kW) with an order of magnitude reduction in weight compared to existing laser systems. With a weight goal of <5 kg/kW, HELLADS will enable high-energy lasers (HELs) to be integrated onto tactical aircraft, and will significantly increase engagement ranges compared to ground-based systems, enabling high precision, low collateral damage, and rapid engagement of fleeting targets for both offensive and defensive missions. The HELLADS program has completed the design and demonstration of a revolutionary prototype unit cell laser module that has	48.300	26.000	11.500	0.000	11.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
demonstrated power output and optical wavefront performance that supports the goal of a lightweight and compact 150 kW high energy laser weapon system with near-diffraction limited beam quality. An objective unit cell laser module with integrated power and thermal management is being designed and fabricated by two laser suppliers and will demonstrate an output power of >34 kW. Based on the results of the unit cell demonstration, additional laser modules will be fabricated to produce a 150 kW laser that will be demonstrated in a laboratory environment. The 150 kW laser will then be integrated with beam control, prime power, thermal management, safety, and command and control subsystems that are based upon existing technologies to produce a laser weapon system demonstrator. The capability to shoot down tactical targets such as surface-to-air missiles and rockets and the capability to perform ultra-precise offensive engagements will be demonstrated in a realistic ground test environment. Additional funding for this integration effort will be provided for HELLADS testing in Project NET-01, PE 0603766E starting in FY 2011. The HELLADS laser will then be transitioned to the Air Force for modification and aircraft integration and flight testing. *FY 2009 Accomplishments:* - Fabricated a prototype unit cell and characterized power output and optical wavefront of the prototype unit cell. - Initiated field testing of individual laser weapon system components. - Performed static lethality testing against key components of targets to be utilized in the field demonstration of the 150 kW laser weapon system. *FY 2010 Plans:* - Complete a unit cell laser module with integrated power and thermal management subsystems and demonstrate power, beam quality, run-time, weight, and volume. - Complete the detailed design of a ground-based 150kW laser weapons system demonstrator. - Initiate fabrication of additional unit cell laser modules to complete the 150 kW laser. - Initiate fabrication of the demonstrator laser weapon system. - Perform demonstrator laser weapon system component and subsystem testing.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiate the fabrication and laboratory testing of the 150 kW laser. - Commence aircraft integration studies and design. *FY 2011 Base Plans:* - Integrate the 150 kW laser with the ground-based demonstrator laser weapon system. - Complete low power and high power testing of the ground-based demonstrator laser weapon system. - Conduct a ground-based field demonstration and analyze initial results of the performance of the demonstrator laser weapon system against tactical targets of interest to the Air Force and other users.					
Aero-Adaptive/Aero-Optic Beam Control (ABC) (U) The goal of the Aero-Adaptive/Aero-Optic Beam Control (ABC) program is to improve the performance of high energy lasers on tactical aircraft against targets in the aft field of regard. In order to achieve high off-boresight targeting capability, current optical turret designs protrude into the flow. This causes severe aero-optic distortions in the aft field of regard due to turbulence in the wake and the unsteady shock movement over the aperture. These distortions decrease the power flux on target (the measure of lethality for a directed energy system) and consequently limit the directed energy system to targets in the forward field of regard. This program will optimize flow control strategies for pointing angles in the aft field of regard. The program will also explore the ability of the flow control system to be synchronized with adaptive optics. This effort will initially focus on wind tunnel testing to prove the feasibility of steady and periodic flow control techniques to reduce or regularize the large scale turbulent structures surrounding an optical turret. These tests will culminate in a hardware-in-the-loop demonstration utilizing flow control with an adaptive optics system in a full-scale wind tunnel test for the turret. Following successful wind tunnel demonstrations, a preliminary design of a flight test turret incorporating flow control will be undertaken. *FY 2009 Accomplishments:* - Used Computational Fluid Dynamics (CFD) analyses to optimize blowing slot configuration.	5.360	4.446	5.100	0.000	5.100

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Assessed wavefront measurements for a range of pointing angles to evaluate system performance in sub-scale tests. - Downselected flow control actuation technique. - Modeled effects of adaptive optics on system performance. - Assessed military utility of system improvements achievable with flow control and adaptive optics. *FY 2010 Plans:* - Design and fabricate ABC optics for full-scale wind tunnel test of turret. - Design and fabricate ABC flow control actuators for full-scale wind tunnel test. - Perform bench-level evaluation of system functionality using phase screens. *FY 2011 Base Plans:* - Perform initial testing of flow control in open-loop testing of ABC turret. - Demonstrate and validate ABC concept with closed-loop adaptive optic system and flow control in a full-scale wind tunnel test.					
High Performance Algorithm Development (U) The High Performance Algorithm Development programs identify, develop and demonstrate new mathematical paradigms enabling maximum performance at minimum cost in a variety of DoD systems applications. The programs look for opportunities to aggressively leverage the power of mathematical representations in order to effectively exploit large-scale computational resources as they apply to specific problems of interest. They also cultivate theoretical breakthroughs in areas of basic mathematics having relevance to emerging defense sciences and technologies. The products are typically advanced algorithms and design methodologies. DARPA is pursuing the development of well-conditioned fast algorithms and strategies for the exploitation of high-dimensional data (i.e., data with a high number of degrees of freedom) in order to deal with a variety of complex military problems including digital representation and analysis of terrain and other geospatial data, efficient high fidelity scattering computations of radar scattering for predictive design and exploitation of radar cross	6.200	5.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
sections, and efficient automatic mapping and optimization of signal processing kernels onto advanced departmental computational hardware architectures. *FY 2009 Accomplishments:* - Developed a quantitative methodology in the area of information propagation, impact and persistence for the military and coalition environment relying on observations from neuroscience, cognitive science and social networking. - Identified the intrinsic signatures of information/target message endurance among disparate groups and cultures through measures of neuroscience and behavior. - Demonstrated that by using the Discovery and Exploitation of Structure in Algorithms (DESA) tools non-expert users can design end-to-end systems in 1/10th the time of expert designers. - Extended DESA tool suite to other common signal processing and image formation algorithms. - Extended time reversal methods to acoustic channels and increased the computational speed of the Green's function by 100. - Employed topological tools to analyze higher-order datasets in biology, sensing, and neuroscience. - Developed geometric theory of higher dimensional clustering for novel data analysis. *FY 2010 Plans:* - Develop the neural signatures for key variables in information propagation and persistence in the brain specifically related to military and coalition operations. - Develop brain imaging methodologies and tasks to specifically measure attributes such as altruism, persuasion, and trust in individuals, dyads and groups. - Develop a comprehensive and quantitative theory of information movement and persistence among individuals and groups to better predict and control responses to specific messages and events. - Implement geometric theory of higher dimensional clustering for novel data analysis to produce user-friendly fast algorithms. - Develop multi-parameter and multi-dimensional topological persistence algorithms to extract high dimensional, dynamic, hidden features in massive data sets across DoD applications; including					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
communications, biology, neuroscience as well as classically important radar and other digitally represented applications. - Develop a new family of non-increasing stochastic processes that enables the replacement of propensity by probability in uncertainty modeling. - Develop an Ito-style stochastic calculus to build theoretical models to improve uncertainty prediction. *FY 2011 Base Plans:* - Develop and use novel topological tools to analyze non-linear dynamical systems. - Design specific information or message content to be delivered in controlled experiments based on insights gained from neural recordings related to key perceptual variables. - Predict information transmission and/or message success solely on the basis of neural pattern activation in the key brain regions. - Demonstrate quantitative nature of brain imaging technologies for information transmission.					
Integrated Sensing and Processing (U) The Integrated Sensing and Processing program will open a new paradigm for application of mathematics to the design and operation of sensor/exploitation systems and networks of such systems by developing and applying novel optimization methodologies for integrating sensing, processing, and information exploitation functionality in sensor systems. This program will create tools enabling the design and global optimization of advanced sensor system architectures comprising fully interdependent networks of functional elements, each of which can fill the roles and functions of several distinct subsystems in current generation sensor systems. Payoffs will include improved performance with reduced complexity of hardware and software in a wide variety of systems, including agile adaptive arrays for missile seekers, unmanned air vehicles, and space-borne sensors; novel waveforms, and novel approaches to multiplexed hyper-spectral chemical/biochemical sensing systems.	7.500	6.400	6.200	0.000	6.200

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Transitioned compression technology to National Geospatial Agency commercial geospatial products. - Extended deterministic theory to cover spaces for network systems and sensing applications. *FY 2010 Plans:* - Extend graph topology to simplex methods to develop novel algorithms in strategy complexes and Bayesian decision trees. - Generate algorithms to provide flexible, movable, reactive border generation for dynamics and unpredictable events. - Develop multi-body algorithms to enable formation flight and interaction of sensors in zero-gravity environments. *FY 2011 Base Plans:* - Develop stochastic topological theory of non-parametric statistics and apply to automatic target recognition problems. - Develop clock-free strongly open-loop controls and information state estimation and comparison for minimal-sensing in localization and navigation problems. - Test multi-body algorithms to enable formation flight and interaction of sensors in zero-gravity environments.					
Training Superiority (U) The Training Superiority program will change the paradigm for military training by creating new approaches to increase technical competence. Passive teaching approaches, including web-based training, will not succeed in instilling the skills and knowledge needed in the new land-battlefield, with higher demands on fewer soldiers, including the need to control and interact with highly technical unmanned systems. These new training approaches will include elements of human-tutor interactions and the emotional involvement of computer games coupled with the fidelity and feedback of Combat	12.371	8.900	8.400	0.000	8.400

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Training Center learning. In addition, this thrust will scale-up new digital tutor methodologies, deliver these to a large cohort of warfighters, and demonstrate a convincing benefit compared to standard training in an operational environment. *FY 2009 Accomplishments:* - Demonstrated Digital Tutor, including teaching one week of content, in a production software configuration, running continuously in Navy schoolhouse setting. - Created and beta tested an additional two weeks of Digital Tutor content, in Navy schoolhouse setting. - Established stand-alone experimental school for collecting and validating data necessary for building full 16 weeks of Digital Tutor content. - Conducted three-stage Information Warfare Cup (IWAR) training effectiveness evaluation in coordination with Navy's 3rd Fleet and Naval Education and Training Command's Center for Information Dominance. Results indicated superior performance of Digital Tutor-trained students over Navy-selected Fleet experts in solving a wide range of Information Technology (IT) challenges in a controlled Laboratory setting; several ship settings; and during deployment. - Digital Tutor-trained students were requested by name to assist in preparing a single Navy ship for its Computer Network Defense in Depth Baseline Assessment. *FY 2010 Plans:* - Develop the underlying engine and the hardware/software architecture necessary to create large scale Digital Tutor system, with focus on scaling, capacity and performance. - Elaborate intrinsic, instrumental and extrinsic motivation models in order to maintain student motivation over two months of instruction demonstrated over one week. - Port two months of Navy IT-School content from a human-tutored course to the Digital Tutor. - Create an automatic capability to identify students requiring remediation. - Develop methodology for establishing correspondence between Digital Tutor content/training and existing Navy curriculum, to facilitate transition of Digital Tutor to Navy Schoolhouse.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Extend Natural Language Understanding to encompass the full range of the IT domain. - Create a semantic model, abstractions, and Application Program Interface (API) that allows Socratic dialogs capable of handling large number of semantic responses rather than a predefined set of answers. - Complete full sixteen weeks of content and integrate results of theoretical work. - Demonstrate deployment to pier-side and harden the system (full course). - Establish effectiveness of Digital Tutor system in creating Mastery-level students by conducting second IWARs competition between Digital Tutor trained students and Navy-selected Fleet experts.					
RealWorld (U) The RealWorld program exploits technical innovation and integration to provide any U.S. warfighter with the ability to open a laptop computer and rehearse a specific mission in the relevant geo-specific terrain, with realistic physics. Because the system will be scalable and distributed, warfighters can practice by themselves, in small groups, or with as many other warfighters as needed for the mission over a local or distributed network, and across all relevant platforms (dismounts, vehicles, helicopters, and fast movers). Most important is the understanding that RealWorld is not a static simulation; it is a simulation builder with applications across the spectrum of modern kinetic and non-kinetic warfare. The program is building tools that allow warfighters to rapidly and easily build their own missions though the introduction of new methodology for building simulation software. These methodologies and adherence to a highly modular approach will cause a fundamental paradigm shift in the acquisition, as well as the construction, of DoD modeling and simulation products. *FY 2009 Accomplishments:* - Demonstrated dynamic path finding such that entities will be able to maneuver in a terrain deformed geo-specific area.	17.473	6.250	5.650	0.000	5.650

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Integrated a full Newtonian physics modeling engine in a real-time 3-D engine in both a hardware enhanced and software only modality. - Transformed a laser imaging detection and ranging (LIDAR) data collection set into a 3-D model (using topology graph analysis and parametric model fitting) capable of being utilized by a real-time 3-D engine. - Ingested up to one square mile of LIDAR terrain data and rendered 3-D models in less than one hour. *FY 2010 Plans:* - Scale to 1000 warfighter entities. - Integrate meteorological capability so real-time weather can be imported into training and rehearsal scenarios. - Demonstrate integration of data from Google Earth. - Transform pictures taken by a cell phone camera into a 3-D model capable of being ingested by a real-time 3-D engine with an accuracy of one or less. *FY 2011 Base Plans:* - Demonstrate ability to support joint air/land/sea operations in a Special Operations Mission Planning Environment (SOMPE). - Integrate RealWorld with a mission planning/C2 system (e.g., SOMPE) and demonstrate two-way data flow. - Add voice capability to avatar system. - Create an application programming interface that will allow external artificial intelligence systems to be easily integrated into RealWorld.					
Efficient Mid-Wave Infrared Lasers (EMIL) (U) The Efficient Mid-Wave Infrared Lasers (EMIL) program will develop efficient solid-state coherent sources to cover the atmospheric transmission bands in the mid-wave infrared (MWIR; 3-5	5.140	3.160	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
micrometers). Infrared countermeasure (IRCM) systems in particular depend on intense sources at these bands. The current generation IRCM systems utilize diode-pumped Thulium (Tm) lasers used to pump optical parametric oscillators, most commonly based on zinc germanium phosphide. (U) The lasers developed in this program will operate across the three relevant bands within the MWIR at 10 W power with wall plug efficiencies of at least 10 percent. By virtue of the enormous volumetric reduction (100-1000 times), power reduction (ten times), and superior pulse format (cw-operation), such sources will enable new architectures and approaches permitting IRCM systems to be deployed on platforms (e.g., rotocraft) which are highly vulnerable to Man Portable Air Defense Systems and other threats but for which current IRCM systems are prohibitive or are inadequate (e.g., unable to defeat staring sensors). At least two diode-based laser approaches will be explored in this program, both involving antimonide-based compound semiconductor materials. These include intersubband-based quantum cascade lasers (QCLs) and type-II antimonide lasers, including so-called “W-configuration” approaches, the name taken from the shape of the conduction band profile. *FY 2009 Accomplishments:* - Scaled the power, in a parallel development, of the efficient individual QCL sources developed previously. *FY 2010 Plans:* - Demonstrate epitaxial growth and preliminary characterization of final structures.					
Revolution in Fiber Lasers (RIFL) (U) The goal of the Revolution in Fiber Lasers (RIFL) program is to develop multi-kilowatt, single-mode, narrow line fiber laser amplifiers using efficient, high brightness laser diode pump arrays. These narrowline fiber laser amplifiers can then be coherently combined to develop ultra-high power electronically steerable optical phased arrays. In Phase 1 of this program, a 1 kW narrowline, single mode, single polarization fiber laser amplifier will be developed with 15% electrical efficiency and a	11.294	10.551	5.368	0.000	5.368

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
beam quality of better than 1.4x diffraction limited. In Phase 2 of this program, a 3 kW narrowline, single mode, single polarization fiber laser amplifier will be developed with 30% overall electrical efficiency and better than 1.4x diffraction limited beam quality. Coherent arrays of these high power fiber laser amplifiers will then be developed as part of the DARPA Adaptive Photonic Phase-Locked Elements (APPLE) program (PE 0603739E, Project MT-15) to achieve the requisite power and coherence for future multi-kilowatt high power laser weapons. *FY 2009 Accomplishments:* - Initiated construction of 1 kW coherently combinable fiber amplifiers (single mode, single polarization, narrow line) that will support development of a high power fiber laser optical phased array and that will provide >15% electrical efficiency and near-diffraction-limited beam quality (M2 < 1.4). - Completed final engineering design of a 3kW, 30% efficient, near-diffraction-limited coherently combinable fiber laser amplifier (single mode, single polarization, narrow line) that will support development of high power fiber laser optical phased arrays for laser weapon applications. *FY 2010 Plans:* - Demonstrate and test 15% efficient, single mode, single polarization, coherently combinable fiber laser amplifiers with near diffraction-limited beam quality at 1kW power level. *FY 2011 Base Plans:* - Demonstrate and test 30% efficient, single mode, single polarization, coherently combinable fiber laser amplifiers with near diffraction-limited beam quality at 3kW power level.					
Coherently Combined High-Power Single-Mode Emitters (COCHISE) (U) The Coherent Combination of High-Power Single Emitters (COCHISE) program will develop kilowatt-class, coherent arrays of single-mode laser diodes at overall electrical efficiencies of 50%. These coherent laser diode arrays will provide not only the power for each sub-aperture, but also the multi-kilohertz bandwidth, sub-centimeter-resolution adaptive optics required to efficiently propagate	1.500	3.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
high power laser beams through the turbulent atmosphere at distances up to multiple kilometers. Such capability is required for Army ground-to-ground and Navy missile defense applications. The program will construct a 2-dimensional array of laser diodes coherently combined at an overall electrical efficiency of more than 40%. The near-field intensity of the array will exceed 300 watts/cm2, to insure compatibility with driving sub-apertures demonstrated in other DARPA programs. *FY 2009 Accomplishments:* - Demonstrated coherent combination of a bar of single mode slab-coupled optical waveguide laser (SCOWL) diodes at 10 W with 1.4x diffraction limited beam quality. - Developed electrical power supply, microscale power distribution, and holographic optical elements to support coherent combination of 10 bars of SCOWL diodes with each bar operating at a power level of 10 watts. *FY 2010 Plans:* - Demonstrate coherent combination of 10 bars of single mode SCOWL diodes at a total power of 100 W with better than 1.4x diffraction limited beam quality and at better than 30% electrical efficiency. *FY 2011 Base Plans:* - Demonstrate coherent combination of 30 bars of single mode SCOWL diodes at a total power of 1000 W with better than 1.4x diffraction limited beam quality at better than 40% efficiency. - Demonstrate coherent combing with high electrical efficiency.					
Fiber Laser Pulse Source (FLIPS)* *Formerly GORGON - High Power Mid-IR Laser (U) The Fiber Laser Pulse Source (FLIPS) program will develop a compact fiber laser system that generates short high-energy pulses, at a high average-power level. The system will enable applications	3.700	3.160	3.000	0.000	3.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
such as remote detection of biological and chemical agents, free space communications, advanced photolithography as well as long-range high-resolution laser-radar systems. (U) Future efforts under this program will include the integration of these technologies into the development of a compact, UAV compatible system that efficiently generates sub-nanosecond duration pulses with peak powers exceeding several megawatts (MW), pushing past fundamental limits of existing fiber based laser amplifiers. The initial intended application for the laser source is a rapidly deployable, UAV based, long-range laser radar tracking system. *FY 2009 Accomplishments:* - Developed a system design for a compact, efficiency high-energy pulsed laser system with a MW-class peak power level. - Performed major system design trades. *FY 2010 Plans:* - Demonstrate techniques for power scaling of pulsed fiber lasers beyond the fundamental nonlinear limitations of individual amplifiers. - Demonstrate environmental robustness of the components and system design to allow for integration on a high-altitude UAV platform. *FY 2011 Base Plans:* - Demonstrate a small-scale laboratory laser system traceable to the final system design. - Demonstrate the ability to phase-lock, control, and synchronize highly nonlinear laser amplifiers for power scaling applications.					
JOULE (U) The JOULE program will exploit new architectures, reversible electrode structures, materials, and chemistries for the development of rechargeable, high energy density batteries that match or exceed	0.000	0.000	4.000	0.000	4.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
energy density of hydrocarbon fuels (e.g. gasoline, JP8, etc.). This technology will target replacing gasoline in both military and civilian transportation applications. These high energy density batteries will also lighten the payload and extend mission capabilities for the dismounted soldier. The program will significantly increase the stoichiometric limits on reducible charge capacity in reversible batteries by developing non-crystalline positive electrode structural materials with lightweight structural approaches and new chemistries. Three-dimensional structures with very high surface areas for electrodes will increase the power density of these batteries. The program will develop new chemistries for positive electrodes to demonstrate reversibility in the graphite fluorite (a high-voltage, high-capacity material) class of positive electrode materials in reversible batteries for the first time. The energy density will increase over ten-fold current lithium ion batteries commonly in use. *FY 2011 Base Plans:* - Investigate chemistry and materials to enable rechargeable high energy density batteries.					
Discharge Excited Catalytic Oxygen Iodine Laser (DECOIL) (U) The Discharge Excited Catalytic Oxygen Iodine Laser (DECOIL) program investigated the potential of the electric oxygen iodine lasers to make maximum use of air (80%N2/20%O2) in the laser device. The DECOIL device is an alternative to the well known chemical oxygen iodine laser (COIL) developed in 1977 and scaled to megawatt (MW) levels. *FY 2009 Accomplishments:* - Demonstrated laser outcoupled power of = 100 Watts. - Demonstrated beam quality (M2) of = 1.2. - Demonstrated wallplug electrical efficiency of = 10 percent.	1.749	0.000	0.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	122.827	81.739	69.018	0.000	69.018

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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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TT-07: *AERONAUTICS TECHNOLOGY*	31.316	31.956	42.334	0.000	42.334	70.431	99.504	90.214	94.245	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) Aeronautics Technology efforts will address high payoff opportunities that dramatically reduce costs associated with advanced aeronautical systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. This includes advanced technology studies of revolutionary propulsion and vehicle concepts, sophisticated fabrication methods, and examination of novel materials for aeronautic system applications.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Helicopter Quieting	4.000	3.800	0.000	0.000	0.000
(U) Studies and analysis of military helicopter operations have shown that the survivability and lethality of U.S. helicopters can be increased by reducing the range at which their acoustic signature can be detected and recognized. The goal of the Helicopter Quieting program is to advance the capability for analytical development of advanced rotor technologies that will dramatically enhance the survivability of military rotor systems while enabling improvements to performance, affordability, availability and suitability. A critical element toward this goal is to create and demonstrate a physics-based toolset that enables analytical design of novel rotor systems and rotorcraft for reduced acoustic susceptibility (detection and recognition) by human and electro-acoustic threats. (U) Current rotor development is very costly involving a time-consuming iterative, trial and error cycle of analysis and model wind tunnel tests, or occasionally, a faster but much riskier analysis path directly to full-scale wind tunnel/flight test. Additionally, the primary limitation of existing computational models is their inability to accurately predict the pressure distribution on a rotor blade and in the flowfield away from the blade. Novel and creative concepts and ideas are being employed in this program for accurate aerodynamic analysis of helicopter rotor airloading, flowfield, and wakes using high-end computational					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
fluid dynamics techniques. The program will develop tools capable of accurately predicting noise signature of advanced rotor concepts that exhibit a significant reduction in low-frequency in-plane signatures. (U) The Helicopter Quieting program will also optimize survivability by developing propagation and perception modeling for rotorcraft acoustic signatures within state-of-the-art visualization architectures. Multiple advanced human perception and cueing models will be developed as a part of the integrated acoustic design and analysis environment. The ability of the toolset to accurately characterize the differences in these factors will support design decisions for advanced rotors and rotorcraft that exhibit dramatically reduced perceptibility. The toolset will also enable assessment of operational tactics, techniques, and procedures, to include pilot technique, toward optimization for survivability. *FY 2009 Accomplishments:* - Demonstrated capability of visualization architecture to incorporate detailed data about rotor configuration, vehicle performance, acoustic signature, terrain & feature mapping, mission profile, and atmospheric conditions as well as variable threat components. - Developed a visual display of value to the mission planner as well as the warfighter. - Transitioned tools to Services, Industry, and Academia. *FY 2010 Plans:* - Identify acoustic design criteria for new rotor system designs based on operational scenarios. - Integrate high-fidelity rotor acoustic signature prediction, physics-based propagation modeling and advanced human perception models.					
Nano Air Vehicle (NAV)* *Formerly Nano-Flapping Air Vehicles.	3.300	2.500	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The goal of the Nano Air Vehicle (NAV) program is to develop a hummingbird-inspired flapping air vehicle technology with less than a five inch wingspan and gross take-off weight of fifteen grams or less. Operations in the urban terrain require sensors that can navigate in difficult terrain and be inserted without being detected. Small air vehicles capable of navigating interior domains without GPS would enable autonomous prosecution of a number of high risk missions that are currently performed by warfighters. Examples of such missions include intelligence, surveillance and reconnaissance (ISR) in buildings, underground facilities, caves, tunnels, and confined urban environments. Key enabling technologies include: flapping wing aerodynamics, kinematics and flight dynamics, lightweight aero-elastically tailored wing structures, miniature navigation systems, micro-propulsion systems, small payloads, and the ability to perch like a bird. *FY 2009 Accomplishments:* - Demonstrated roll-pitch-yaw control of a hovering, flapping air vehicle using only wing-stroke modulation, modeled after birds and insects. This is a first in the history of aviation. - Demonstrated sustained hover of a flapping air vehicle. - Developed preliminary design of a flapping wing nano air vehicle and control system to assist platoon/squad level operation in urban and indoor environments. - Demonstrated on-board, closed-loop control using miniature inertial sensors and micro actuators. *FY 2010 Plans:* - Demonstrate mission-relevant flight times of >5 minutes hovering and >10 minute forward flight. - Develop preliminary user controller and onboard vehicle navigation system to permit robust remote-controlled flight. - Demonstrate prototype vehicle in simulated combat missions and other realistic environments.					
Battlefield Helicopter Emulator (BHE) (U) The goal of the Battlefield Helicopter Emulator (BHE) is to develop a system capable of emulating rotorcraft signatures, compatible with installation as a payload on a small unmanned aerial system	3.514	3.356	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(UAS). The system will provide helicopter signature emulation of a variety of battlefield helicopters. BHE could be used for mine clearing/route determination as well as escort missions. An operational system could draw fire from ground based adversaries, and relay the information back to the operator for off-board location and prosecution. The system offers the opportunity to protect a large number of military aircraft assets and crews over long periods without aircraft performance impact. The reduced acoustic perception distance enabled by the BHE system can reduce the risk to Army and Special Operations Command helicopters from various hostile threats. *FY 2009 Accomplishments:* - Demonstrated numerous emulator systems in multiple signature bands in a field test. - Selected emulator systems for integration with a UAS. *FY 2010 Plans:* - Develop plan for installation, integration, and test on tactical unmanned aircraft. - Develop system Concept of Operations and tactics, techniques and procedures for employment.					
Formation Flight* *Formerly Drag Reduction Flight Demonstration. (U) The Formation Flight program will explore the development of drag reduction technologies for aircraft. Drag reduction allows aircraft to fly at increased ranges, reduces fuel consumption, and may allow increased payload capacity. Formation flight is used in nature by geese and other migratory birds to reduce drag, but requires the development of an autonomous system to maintain the optimum position for drag reduction to be practical for long duration aircraft flights. Safety of flight considerations require aircraft separation distances of up to one mile, necessitating automated sensing and tracking algorithms to track the lead aircraft wake. Flight testing a formation flight configuration will allow structural excitation and vehicle dynamic response to be addressed in proximity to the lead aircraft wake.	3.200	8.000	11.311	0.000	11.311

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Assessed mission benefit of formation flight for a typical mobility mission of a brigade deployment. - Assessed integration approaches for a formation flight system on legacy transport aircraft. - Identified approaches for autonomous control of aircraft to maintain position in the optimal location for formation flight benefits. *FY 2010 Plans:* - Conduct detailed flight test planning for assessment of autopilot faults, alarms, and structural response of the aircraft wing in proximity to the aircraft wake. - Conduct detailed stability and control law assessments for aircraft-wake interactions and trim effects. - Evaluate existing database of wake crossings to determine impacts on flight control systems. *FY 2011 Base Plans:* - Conduct flight tests in the wake of a lead aircraft to quantify structural excitation and stability margin in proximity of a lead aircraft wake. - Develop control algorithms and evaluate control strategies using high fidelity aerodynamic models which include the effects of formation flight.					
Mission Adaptive Rotor (MAR)* *Formerly Active Rotor. (U) The goal of the Mission Adaptive Rotor (MAR) program is to develop and demonstrate the capability to achieve dramatic improvements in rotor performance, survivability, and availability through the use of technologies that enable adaptation of the rotor throughout military missions and/or mission segments. Recent research indicates that significant performance benefits could be achieved by actively morphing the shape or properties of the rotor system, additionally, active rotors with on-blade control could eliminate the need for a rotor swashplate. MAR capability will result in dramatic improvements in	4.695	8.300	11.823	0.000	11.823

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
system performance, operational availability, sustainability, and survivability, including reduction in acoustic susceptibility and rotor vibration while increasing useful payload fraction and range. (U) The MAR program will mature active rotor technologies that enable the effective operation of military rotorcraft in performance-limited environments of high-altitude mountainous terrain and deserts. The MAR program will also focus on development of advanced technologies for application to future helicopter, tiltrotor, and other rotorcraft platforms, with demonstration on a fielded system to enable application to new systems as well as facilitate upgrade of current multi-service rotorcraft systems. *FY 2009 Accomplishments:* - Evaluated concepts for novel adaptive rotor systems. - Characterized performance, survivability, support opportunities, and benefits of adaptive rotor technology. *FY 2010 Plans:* - Initiate conceptual designs of demonstrator rotor system. - Conduct component technology demonstrations and initiate preliminary design of the MAR system. *FY 2011 Base Plans:* - Define quantitative results of design trade studies and risk mitigation assessments. - Initiate preliminary design of the MAR demonstration system. - Define a rotor system design for technology demonstration. - Complete objective system application development and initial requirements definition.					
Advanced Aeronautic Technologies (U) The Advanced Aeronautics Technologies program will examine and evaluate aeronautic technologies and concepts through applied research. These may include feasibility studies of novel or emergent materials, devices and tactics for air vehicle applications, as well as manufacturing and	0.000	0.000	2.000	0.000	2.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
implementation approaches. The areas of interest range from propulsion to control techniques to solutions for aeronautic mission requirements. The result of these studies may lead to the design, development and improvement of prototypes. *FY 2011 Base Plans:* - Conduct feasibility and trade studies of candidate technologies and architectures. - Perform military utility analyses of proposed tactics and concepts of operation.					
Transformer (TX) Vehicle (U) The Transformer (TX) Vehicle program will examine the feasibility and approaches for developing vertical take-off and landing, road-worthy vehicles that carry a 4-person payload >250 NM on one tank of fuel, can safely travel on roads, and can be operated by a typical soldier. The goal is to define the major components and overall design of a TX vehicle that would be suitable for military scouting, personnel transport, and logistics missions. Technical areas that will be explored include: hybrid electric drive ducted fan propulsion system, ring motors, energy storage methods such as batteries and ultra capacitors, morphing vehicle bodies, and advanced flight controls and flight management systems. The TX vehicle is intended to make roads irrelevant for military small unit maneuvers. These units can use TX air vehicles to fly over obstacles or impassible terrain, avoid ambushes and improvised explosive devices (IEDs). Personal TX vehicles could be dispatched for downed airman recovery or for evacuating injured personnel from difficult to access locations, or to resupply isolated small units. Four-man versions would be suitable for enhanced company operations concepts which would allow the soldier/team to see the situation and pick the best place to "drop in" for urban operations. *FY 2010 Plans:* - Conduct trade studies of vehicle designs, lift motors, flight dynamics and control, energy conversion and storage, vehicle architectures, and concepts of operation. - Initiate preliminary design studies. - Conduct risk reduction experiments and modeling to validate designs.	0.000	6.000	12.100	0.000	12.100

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Conduct preliminary design review of TX concepts. - Initiate TX critical design activities.					
Counter-Unmanned Air Vehicles (C-UAV) (U) The components to construct long range, autonomous unmanned air vehicles (UAVs) are ubiquitous. Off-the-shelf hobbyist navigation systems are capable of following GPS waypoints. Vision based systems can track roads or follow on-the-ground moving targets. Small engines and payloads can be accommodated in relatively small aircraft. Slow, low-altitude UAVs are difficult to distinguish from migratory birds, or even ground vehicles, and are frequently filtered out of radar systems by clutter filters for this reason. These vehicles pose a threat to future military operations. Already, UAVs have been used in combat operations against allies of the United States. Countries with little or no capability to field a manned air force are using UAVs for surveillance and reconnaissance. In the future, the electronics required to navigate and control these aircraft will become increasingly available and affordable. The Counter-Unmanned Air Vehicles (C-UAV) program will investigate methods for defeating such threats. The program will study a range of technologies from detection, to tracking and identification of UAVs, to intercept or defeat. Traditional detection systems, used for large manned aircraft, require modification to detect small, slow, low-altitude UAVs. Data fusion from multiple sensors may be required to unambiguously identify small UAVs and differentiate them from other objects such as birds and ground vehicles. The intercept of these UAVs, which may be launched from close range, may require novel approaches. *FY 2011 Base Plans:* - Assess current UAV threats; classify types of vehicles and missions. - Assess current UAV detection capabilities, including radar, acoustic, vision-based, infrared, and capabilities of each. - Perform initial assessment of viable approaches to UAV detection.	0.000	0.000	5.100	0.000	5.100

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*	**PROJECT** TT-07: *AERONAUTICS TECHNOLOGY*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Integrated Compact Engine Flow Path (U) The goal of the Integrated Compact Engine Flow Path program was to fully integrate the aircraft structure and propulsion flowpath. The program evaluated multiple distributed inlets and nozzles to determine if they would allow a better integrated wing and propulsion system, exploiting aerodynamic control possible with engine blowing and suction. *FY 2009 Accomplishments:* - Performed design trade studies to develop a preferred engine/airframe integration design using many small fans and a single large turboshaft engine.	1.000	0.000	0.000	0.000	0.000
Adaptive Morphing Super-Maneuver Aircraft (AMSMA) (U) The goal of the Adaptive Morphing Super-Maneuver Aircraft (AMSMA) program was to demonstrate the practicality and the operational value of morphing aircraft technology in a full scale flight demonstration. The AMSMA approach was to build on the small scale demonstrations of the Morphing Aircraft Structures (MAS) program. The program goal was to demonstrate an advanced morphing, highly maneuverable air vehicle that achieves high fuel efficiencies, translating to prolonged endurance times. *FY 2009 Accomplishments:* - Identified capabilities, critical technologies, survivability approaches and performance goals for the morphing aircraft concept. - Established concept vehicle performance and operating goals.	1.607	0.000	0.000	0.000	0.000
Vulcan (U) The goal of the Vulcan demonstration program is to design, build, and ground test a Constant Volume Combustion (CVC) technology system that demonstrates a 20% fuel burn reduction for a ship based power generation turbine. CVC has been under development for more than a decade.	10.000	0.000	0.000	0.000	0.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Considerable progress has been made and the technology is believed mature enough to enable a dramatic new system capability. CVC, when combined with turbine engines, offers the ability to design a new class of hybrid turbine power generation engines and Mach 4+ air breathing engines. The Vulcan system will consist of a full scale CVC, a compressor, and a turbine. CVC architectures could include Pulsed Detonation Engines (PDEs), Continuous Detonation Engines (CDEs) or other unsteady CVC architectures. The CVC demonstrated in the Vulcan program would have direct application to aviation turbine engines, ship propulsion turbine engines, high mach air breathing engines, and commercial power turbine engines. This program is funded in PE 0603286E, Project AIR-01 in FY 2010-11. *FY 2009 Accomplishments:* - Completed engine system requirements review. - Identified technical risks and developed a critical technology development plan. - Developed Vulcan engine performance models.					
Accomplishments/Planned Programs Subtotals	31.316	31.956	42.334	0.000	42.334

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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*	**PROJECT** TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*	60.918	73.132	62.497	0.000	62.497	36.515	43.945	44.321	44.263	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Network Centric Enabling Technology project provides technology to build mission applications explicitly tailored to exploit the promise of network-centric system architectures. Mission applications include signal processing, detection, tracking, identification, situation understanding, planning, and control functions. These applications will integrate: 1) external sensors and processors that provide data on targets and mission contexts; 2) external platforms, both air and surface, that deliver sensors and munitions to designated areas; 3) intelligence processing systems at all levels of command; and 4) external communications networks that provide connectivity between computing nodes located on the platforms, at field command centers, and headquarters. The mission applications share data to form consistent battlespace understanding tailored to the needs of commanders at each node. The types of tailoring include common operational pictures, timelines, and resource usage descriptions. The mission applications also negotiate plans for future operations based on mission needs presented at each node. To maintain focus on operationally relevant problems, the project's technical goals are posed and evaluated in the context of mixed manned/unmanned forces.

(U) Technologies developed in this project enable localized and distributed collaborative processing. This allows networks of sensors to rapidly adapt to changing force mixes, communications connectivity, and mission objectives while enabling distributed command and intelligence systems to effectively collaborate in a dynamic environment. Technologies are demonstrated and evaluated in the laboratory and in hardware-in-the-loop demonstrations. Demonstrations employ both stationary and autonomous mobile platforms. Operational benefits are: 1) smaller forward deployment of image and signal analysts in complex operating conditions including urban battlefields; 2) deeper understanding of the evolving stability and support operational environment; 3) consistent integration of target and environment information; and 4) flexible operational tactics and procedures to find evasive targets in difficult environments.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Video and Image Retrieval and Analysis Tool (VIRAT) (U) The Video and Image Retrieval and Analysis Tool (VIRAT) program will develop and demonstrate a system for video data exploitation that enables an analyst to rapidly find video content of interest from archives and to provide alerts to the analyst of events of interest during live operations. The	16.241	15.159	13.716	0.000	13.716

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
ability to quickly search large volumes of existing video data and monitor real-time video data for specific activities or events will provide a dramatic new capability to the U.S. military and intelligence agencies. Currently, video analysis for Predator and other aerial video surveillance platforms is very labor intensive, and limited to metadata queries, manual annotations, and “fast-forward” examination of clips. The software tools developed under VIRAT will radically improve the analysis of huge volumes of video data by: 1) alerting operators when specific events or activities occur at specific locations or over a range of locations and; 2) enabling fast, content-based searches of existing video archives. The VIRAT program is developing innovative algorithms for activity representation, matching and recognition which can support both indexing and retrieval. The primary focus of VIRAT is activity-based and dynamic information. Object/scene matching and recognition are also of interest, but only to the extent they support activity analysis. The final product of the VIRAT program is a system that can be transitioned to and integrated within an operational military system, such as the Distributed Common Ground System (DCGS). *FY 2009 Accomplishments:* - Developed multiple initial sets of descriptors for activities in videos. - Developed initial indexing methods for activity descriptors and several search methods against those indices. - Developed initial interactive query refinement methods to fine tune and improve the query and retrieval process. - Developed preliminary interactive retrieval processes to either alert the user or return to the user matching "activities of interest". *FY 2010 Plans:* - Refine and further develop critical technologies to accommodate concatenated and more complex activities. - Continue developing efficient indexing and interactive retrieval against thirty activities.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Extend development of the interactive retrieval process to incorporate improved algorithms and enhanced human factors. - Introduce other airborne video sources and ensure that activity descriptor extraction technologies can still perform as needed. *FY 2011 Base Plans:* - Further develop critical technologies to accommodate stationary, ground-mounted video sources. - Continue developing efficient indexing and interactive retrieval against sixty activities. - Complete development and optimization of critical technologies to accommodate larger datasets. - Integrate final prototype system in accordance with the architecture of the Program of Record transition target. - Finalize system transition efforts and formalize concept of operations for transition to operational activities.					
Home Field (U) The Home Field program develops networked video and Laser Detection and Ranging (LADAR) processing technology to rapidly and reliably update a 3-Dimensional (3-D) model of an urban area. It provides 3-D situational awareness with sufficient detail and accuracy to remove the "home field advantage" enjoyed by opponents. Detailed mobility maps to support ground vehicle routing will be inferred and generated, and detailed visibility data to support sensor positioning will then be derived to maximize coverage and minimize detectability. High fidelity baselines will be created to support change detection to cue searches for targets and anticipate changes due to current or impending meteorological events. The program will supply real-time context information to sensor managers, maneuver controllers, weapons operators, and commanders. Furthermore, the program will filter natural change from artificial change indicative of human (threat) activity and permit operation of military forces in hostile terrain normally deemed favorable to opponents because of their historical familiarity with hide points, sight lines, and mobility characteristics.	12.513	20.578	8.225	0.000	8.225

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) Drawing upon technologies developed in the Home Field program, the Urban Photonic Sandtable Display (UPSD) program is developing revolutionary interactive holographic displays for complex volumetric 3-D data to replace current 3-D visualization technologies that are either static or have limited effective field-of-view. Current technologies include traditional holography, computer graphics on 2-Dimensional (2-D) screens, slice stacking, parallax autostereo, and goggles/glasses. These techniques not only give a poor image quality and poor movement, they also are not created quickly and do not allow for collaborative viewer interaction. The desire to improve these components has launched the development of the UPSD. Applying the design fundamentals of the monochrome active grouping of pixels for a light modulator element into a single 3-D holographic pixel (hogel-based proof-of-concept) display and further developed module, a scalable and tileable laboratory prototype has been validated by transforming computer data to optical data, making sophisticated integration possible to optimize image quality. The UPSD program will develop an affordable 3-D display that operates at full video rate, displays red-green-blue (RGB) color, increases viewing angle, and increases display size. The result will be the world's first full-motion, full aspect 3-D imaging technology system. Utilizing the technologies developed under the Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM) program in ELT-01, the Emissive Micro Displays program will develop technologies to support the fabrication of Low-cost High pixel density Power efficient Direct emission Microdisplays (LHPDM). Current microdisplay systems use light modulation systems (liquid crystal displays, digital micromirror devices,) and by using LHPDM, it will enable the transmission of larger fractions of light from the illumination source. *FY 2009 Accomplishments:* - Researched advanced technologies for improving the production methods of pixilated emissive displays. - Demonstrated the final reconfigurable system at full video rate, color display, and with the capability of tiling to larger display scales (e.g., 6-feet by 6-feet). - Developed cost effective synthesis methods for Group II-VI and III-V materials.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Utilized controlled arrays of indium gallium nitride (InGaN) to form high efficiency Light Emitting Diode (LED) structures and imaging sensors in IR. *FY 2010 Plans:* - Assemble layer-by-layer heterostructures (characterized by dissimilar materials with non-equal bandgaps) from ordered planar arrays of nanocrystals. - Develop and demonstrate techniques for layer doping of heterostructure materials. - Evaluate and select approaches for the development of affordable emissive microdisplays. - Demonstrate initial LHPDM. - Select fabrication technologies with five times cost reduction potential. - Commence demonstration of fabrication technologies that support the fabrication of affordable emissive microdisplays. *FY 2011 Base Plans:* - Complete demonstration of fabrication technologies that support affordable emissive microdisplays.					
Integrated Crisis Early Warning System (ICEWS) (U) The Integrated Crisis Early Warning System (ICEWS) program develops and integrates a set of data analysis tools into a unified information system to support Theater Security Cooperation (TSC). The ICEWS system monitors, assesses and forecasts leading indicators of events that make countries vulnerable to crises. ICEWS technologies include quantitative and computational social science modeling and simulation, scenario generation, ontological modeling of security problems, advanced interactive visualization techniques, and agent-based programming. When integrated, these tools allow combatant commanders and their staff to understand and anticipate conditions that precipitate instability and conflict while there is still time to influence them. ICEWS also helps anticipate unintended consequences of actions taken to influence or remediate situations, consequences that may be delayed by months or years.	10.608	10.195	5.063	0.000	5.063

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed a prototype system to systematically filter millions of digital news reports of global political events, making them easily searchable and visually displayed on timelines by country, theme and actor. - Identified preliminary patterns in how U.S. diplomatic, information, military, and economic (DIME) actions influence factors associated with nation-state crises and instability. *FY 2010 Plans:* - Conduct in-theater test and evaluation of ICEWS at PACOM HQ. - Develop tools that can be transitioned to the staff at Combatant Commands (PACOM HQ). *FY 2011 Base Plans:* - Refine the system based upon user feedback and transition to PACOM HQ.					
Extreme Accuracy Tasked Ordnance (EXACTO) (U) The objective of the Extreme Accuracy Tasked Ordnance (EXACTO) program is to revolutionize rifle accuracy and range by developing the first ever guided small caliber bullet. The EXACTO 50-caliber round and optical sighting technology will more than double the day and nighttime range over current state-of-the-art sniper systems while allowing the sniper to prosecute moving targets even in high wind conditions, such as those commonly found in Afghanistan. Prosecution of these types of targets is impossible with current technology. This system will not only improve sniper effectiveness, but also enhance troop safety by allowing greater shooter standoff range and reduction in target engagement timelines. The system combines a maneuverable bullet and a real-time guidance system to track the target and deliver the projectile to target. Technology development includes the design and integration of aero-actuation controls, power sources, optical guidance systems, and sensors. The components must fit into the limited volume (2 cm to the third power) of a 50-caliber projectile and be designed to withstand a high acceleration environment. The EXACTO technology is planned for transition to the Army by FY 2012.	15.670	19.700	22.218	0.000	22.218

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Designed guidance system. - Designed maneuverable projectile. - Constructed all novel 1x scale components. - Performed successful live fire tests of guidance system and key components. *FY 2010 Plans:* - Demonstrate potential system performance using Hardware-in-the-Loop (HITL) simulation based on measured component and subsystem performance, at a number of ranges under varying environmental and target conditions. - Perform initial system integration of all subsystems. - Evaluate initial integrated system performance in the laboratory. *FY 2011 Base Plans:* - Revise component and system design as necessary to meet design goals. - Conduct initial field testing of weapon system under controlled conditions. - Optimize system design. - Demonstrate field performance of complete system under realistic, but controlled, conditions.					
Digital Media Exploitation (MEDEX) (U) The Digital Media Exploitation (MEDEX) program will develop technology to extract intelligence of tactical value from digital media found on computers captured in the field. MEDEX will automatically search content (text documents, audio files, images, videos, applications, etc.) and identify data of high intelligence value. Traditionally, the objective of a digital media exploitation system has been to extract content for later analysis, so accuracy (e.g., precision and recall) and scalability to multiple processors for large data volumes have been emphasized. However, warfighters may have very limited time to process the data for key evidence that may result in tactical advantage; therefore, speed and accuracy are critical. The MEDEX program will develop digital media exploitation technology suitable for tactical	0.000	0.000	4.275	0.000	4.275

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
environments which have constrained computational resources, accelerated operational timelines, and specific intelligence objectives. The MEDEX program will develop fast algorithms and techniques for processing evidence from digital media to deliver distilled intelligence that is accurate and scalable to large datasets, and can execute quickly on a single mobile computing platform, such as a notebook or ultraportable computer. *FY 2011 Base Plans:* - Develop automated media exploitation algorithms that determine the intelligence value based on content analysis of text, image, and video files. - Integrate algorithms into a digital media exploitation platform capable of producing a human-readable summary of the content of a captured hard drive. - Demonstrate intelligence extraction by testing digital media. - Develop alternative imaging techniques for hard drives, which enable their contents to be replicated rapidly onto another storage media device. - Develop methods for extracting geospatial intelligence from digital multimedia. - Integrate MEDEX technology into a portable digital media triaging system.					
PERsistent Stare Exploitation and Analysis System (PerSEAS) (U) The PERsistent Stare Exploitation and Analysis System (PerSEAS) program will develop and demonstrate a tool to automatically and interactively identify events of interest from persistent, wide area, motion imagery data with support from signal intelligence and other sources. Persistent, wide area surveillance imagery is an ever increasing source of operational data, but exploitation of this data at present is mostly manual and requires hours to days to produce results. Tools are needed to automatically detect potentially significant adversary activities and to discriminate these from nominal background activity. These tools would be supported by libraries of activity patterns, logic to generate hypotheses about which activities are being observed, and mechanisms to quantitatively score the consistency of the data with each activity hypothesis. Such capabilities are necessary to detect and	0.000	7.500	9.000	0.000	9.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
defeat threats in real-time. The major thrust of the program is the processing of extracted features (such as context and tracks) to yield events of interest, which in turn would be linked to form activities and then integrated to discover potential threat patterns. The discovery and identification of the potential threat patterns would then produce alerts and cues. PerSEAS technologies and system are planned for transition to the Distributed Common Ground Station and other intelligence applications. *FY 2010 Plans:* - Formulate approaches to network discovery based on normalcy estimates, improved tracking algorithms using pattern analysis, and contextual analysis for anomaly detection. *FY 2011 Base Plans:* - Implement and evaluate techniques on wide area motion imagery data. - Develop a system prototype.					
Automated Battle Management (U) The Automated Battle Management program developed novel technologies for multi-platform, automated battle management at the tactical level, in the air, the sea, on the ground, and within mobile sensor networks. Such technologies enable U.S. forces to keep up with the increasing pace of battle as more-capable platforms and higher-bandwidth communication networks become operational. (U) The Collaborative Networked Autonomous Vehicles (CNAV) effort was the primary demonstration of Automated Battle Management techniques. CNAV developed autonomous control methods to cause a distributed set of unmanned undersea vehicles to self-organize and distribute tasks through judicious transactions conveyed over a shared communications network. CNAV utilized these capabilities to provide submerged target detection, localization, and tracking in restrictive littoral waters. CNAV created a field of vehicles, networked through acoustic wireless communications. The vehicles worked collaboratively and autonomously to detect, classify, localize and track target submarines transiting the	5.886	0.000	0.000	0.000	0.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
field. The field was capable of self-organizing to adapt to changes in target locations, environmental conditions, and operational factors. *FY 2009 Accomplishments:* - Demonstrated collaborative automated target detection, classification, localization and tracking. - Demonstrated self-healing and reconfiguration, and threat pursuit and interception.					
Accomplishments/Planned Programs Subtotals	60.918	73.132	62.497	0.000	62.497

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	238.172	270.207	312.586	0.000	312.586	254.218	273.710	279.524	292.860	Continuing	Continuing
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	117.721	141.362	175.586	0.000	175.586	134.218	153.710	159.524	172.860	Continuing	Continuing
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	120.451	128.845	137.000	0.000	137.000	120.000	120.000	120.000	120.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

(U) The Biologically Based Materials and Devices Project acknowledges the growing and pervasive influence of the biological sciences on the development of new materials, devices and processes, as well as the commensurate influence of materials, physics and chemistry on new approaches to biology and biochemistry. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the development of biochemical materials to maintain performance, the use of biology's unique fabrication capabilities to produce structures that cannot be made any other way, the application of magnetic materials in biological applications, and the development of manufacturing tools that use biological components and processes for material synthesis. It also supports a major thrust that will revolutionize the development of prosthetics for the wounded soldier.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	282.896	268.859	0.000	0.000	0.000
Current President's Budget	238.172	270.207	312.586	0.000	312.586
Total Adjustments	-44.724	1.348	312.586	0.000	312.586
• Congressional General Reductions		-1.132			
• Congressional Directed Reductions		-7.000			
• Congressional Rescissions	-8.776	0.000			
• Congressional Adds		9.480			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-28.000	0.000			
• SBIR/STTR Transfer	-7.948	0.000			
• TotalOtherAdjustments	0.000	0.000	312.586	0.000	312.586

Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2009	FY 2010
Project: MBT-01: *MATERIALS PROCESSING TECHNOLOGY*		
Congressional Add: *Strategic Materials*	4.400	5.000
Congressional Add: *Synthetic Fuel Innovation*	4.000	0.000
Congressional Add: *Center for Nonproliferation Studies, Monterey Institute for International Affairs*	0.000	1.600
Congressional Add: *Photovoltaic Ribbon Solar Cell Technology Project*	0.000	2.880
Congressional Add Subtotals for Project: MBT-01	8.400	9.480
Congressional Add Totals for all Projects	8.400	9.480

Change Summary Explanation

FY 2009

Decrease reflects Omnibus Reprogramming action for the H1N1 vaccine development, Section 8042 rescission of the FY 2010 Appropriations Act, internal below threshold reprogramming and SBIR/STTR transfer.

FY 2010

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY*

Increase reflects the congressional adds (as identified above) offset by reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts.

FY 2011

Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	117.721	141.362	175.586	0.000	175.586	134.218	153.710	159.524	172.860	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Materials Processing and Manufacturing (U) The Materials Processing and Manufacturing thrust is exploring new manufacturing and processing approaches that will dramatically lower the cost and decrease the time it takes for DoD systems to be fabricated. It will also develop approaches that yield new materials and materials capabilities that cannot be made through conventional processing approaches. Included are disruptive manufacturing approaches for raw materials and components. *FY 2009 Accomplishments:* - Expanded advanced carbon fiber manufacturing techniques from research line to pilot production line while maintaining properties that are in excess of 500 Kilos per square inch in strength, and 42 million pounds per square inch in modulus. - Made over 180,000 ft of nanotube enhanced carbon fiber for testing and evaluation. - Demonstrated ability to use fiber as woven mat in pre-preg for composite structures. - Demonstrated economical tooling for low volume production of polymer matrix composite (PMC) (10-25 units of a hat stiffened plate) that operates at less than 200 degrees Celsius cure temperature.	11.466	13.300	18.100	0.000	18.100

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Verified PMC subcomponent (containing critical details) meets static, fatigue, and destructive evaluations. - Demonstrated a technology readiness level of four on full-size manufacturing of non-autoclave PMCs. *FY 2010 Plans:* - Demonstrate ability to control defect type, size, and concentration to optimize carbon fiber properties. - Start evaluation and testing by Air Force Composites Testing Lab to establish first generation advanced carbon fiber insertion points within Air Force (AF) systems. - Initiate carbon nanotube templating as a means of alleviating nano-scale defects and enhancing carbon fiber tensile strength and modulus. - Enhance carbon fiber properties via cross-planar bonding induced by post-processing neutron irradiation, covalent element (B, N, P, S, etc.) doping, and/or high-strength magnetic field graphene plane alignment. - Transition non-autoclave tooling and materials/processes to large-scale PMC fabricators. - Produce functional, integrally cored molds suitable for turbine foil casting trials at commercial foundry. - Demonstrate capability of out-of-the-autoclave PMC curing to fabricate large complex parts such as co-cured rib/spar structures and multi-pocketed sandwich structures for a high altitude long endurance vertical tail aircraft. - Expand the application of manufacturable gradient index optics (GRIN) by providing compact, lightweight, and cost-effective lenses with controlled dispersion and aberrations that will replace large assemblies of conventional lenses. *FY 2011 Base Plans:* - Demonstrate microstructure/property/process relationship needed for overcoming critical defect limitations in carbon fiber performance for structural applications.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate ability to control defect type, size, and concentration to optimize carbon fiber properties. - Demonstrate successful casting of superalloy turbine blades using ceramic molds made or produced via direct digital manufacturing. - Produce and orient seed crystals in a robust and scalable manner for use in solid state self assembly of single crystals. - Control grain growth during single crystal self assembly to produce single crystals without trapped porosity and low dislocation densities. - Demonstrate GRIN lenses in imaging and non-imaging applications such as a high-resolution imager for a micro-UAV and solid state-tracking solar concentrator, and demonstrate the manufacture of custom lenses in single and high volume lots.					
Structural Materials and Coatings (U) The Structural Materials and Coatings thrust is exploring and developing new materials that will provide enhanced structural and/or surface properties for DoD applications. Included are approaches that avoid corrosion, provide superior strength at greatly reduced material density, provide the basis for a new generation of structural composite and submarine propeller materials, and enable prolonged lifetimes for DoD systems and components. *FY 2009 Accomplishments:* - Completed flow model for 500 pounds per day reactor. - Created energy blueprints for 500 pounds per day prototype reactor. - Verified titanium costs are less than four dollars per pound. - Produced solid and hollow sets of aluminum (Al) based amorphous turbine engine fan blades that meet all dimensional and mechanical property requirements. - Constructed structural unitized multifunctional calcium (Ca) based amorphous metal hybrid panel to validate performance of thermal management and load carrying capability over the temperature range of minus 200 to plus 200 degrees Fahrenheit.	8.791	15.498	16.452	0.000	16.452

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrated reproducible, corrosion-resistant, wear-resistant, and impact-resistant naval advanced amorphous coatings for corrosion prevention and non-skid applications. - Finalized preparations for applications of naval advanced amorphous coatings in small-scale demonstrations on naval combatants. - Initiated development of regenerative skin to prevent biofouling based upon continuous water activated film formation/dissolution concept. - Established initial conditions necessary to tailor formation and dissolution of the anti-biofouling skin, and these conditioned effects on rheological and mechanical properties. *FY 2010 Plans:* - Demonstrate commercially pure titanium from oxide at a production rate of 500 pounds per day. - Quantify structural amorphous metal performance and specific fuel consumption attributes for both military and commercial engines. - Demonstrate coatings of structural hybrid amorphous metal fan blades that successfully meet galling and environmental requirements. - Identify multiphase composite materials suitable for use at high temperatures. - Determine composite material volume fraction, distribution and morphology to obtain optimum structural properties including compressive strength, damage tolerance and environmental resilience. - Identify candidate material systems, manufacturing methods, and quality control procedures to fabricate a high-quality, thick-section, multi-material tapered beam extensible to a doubly-curved, full-scale, multi-material rotor blade fabrication. - Begin design for the thick-section multi-material tapered beam (70 percent of the weight, equivalent stiffness, and 2x performance of a nickel aluminum bronze (NAB) alloy 95800 tapered beam). - Initiate the development of multi-physics Coupling Software Environment (CSE) architecture providing a clear articulation of the domain code coupling (i.e., coupling of Computational Fluid Dynamics (CFD), Computational Structural Mechanics (CSM), and Computational Hydro-acoustic (CHA) models).					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Demonstrate meltless titanium consolidation. - Plan for space launch of structural amorphous composite hybrid panels. - Demonstrate mechanical properties of unreinforced and reinforced multiphase polymers. - Establish structural properties of composite materials as a function of temperature. - Establish damage tolerance following subsonic and supersonic foreign object impact. - Fabricate and test constant cross-section multi-material beam manufacturing demonstration articles (70 percent of the weight with equivalent stiffness of a nickel aluminum bronze (NAB) beam). - Fabricate multi-material panel manufacturing demonstration articles for experimental modal analysis (2x NAB panel performance). Conduct modal analysis. - Develop and initiate demonstration of non-destruction evaluation techniques and associated calibration standards to detect all defects greater than 2 inches in diameter in the hybrid multi-material. - Fabricate and test thick-section multi-material tapered beam (70 percent of the weight, equivalent stiffness, and 2x performance of a NAB tapered beam). - Continue development and initiate verification of the coupling software environment including the hybrid multi-material rotor (HMMR) model/domain code coupling.					
Multifunctional Materials and Structures (U) The Multifunctional Materials and Structures thrust is developing materials and structures that are explicitly tailored for multiple functions and/or unique mechanical properties. This thrust also explores novel materials and surfaces that are designed to adapt structural or functional properties to environmental and/or tactical threat conditions. Included in this thrust are efforts that will lower the weight and increase the performance of aircraft, enhance the efficiency of turbines, improve the survivability of space structures, increase dampening of structural loads, and improve the performance of surface dominated properties (friction and wear, membrane permeability, etc.).	10.810	13.200	25.416	0.000	25.416

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Demonstrated robust adherence of glass coating and textured polymer in order to produce superhydrophobic surfaces on various substrates. - Increased carbon nanotube (CNT) cold cathode performance to 120 milliampere per centimeter squared, and demonstrated ability to grow multi-wall nanotubes decorated with gallium nitride (GaN), ruthenium oxide (RuO2), boron (B), and titanium nitride (TiN) for increased field emission properties. - Demonstrated reduced scattering and losses due to perturbations and damage that might occur on surface wave controlling and power transmitting media. - Initiated the design of new membranes and technologies for particle separation to reduce the clogging and fouling of desalination systems. - Decreased state-of-the-art (SOA) response time for electrochemical double layer capacitor by a factor of 1000 (SOA was approximately 10 milliseconds; tested capacitor responded in approximately 20 microseconds). *FY 2010 Plans:* - Demonstrate ability to multiplex surface waves and power transmission onboard spacecraft. - Demonstrate ability to surface harden appropriate naval alloys and geometries for propulsion systems in large scale. - Finalize the design of new membranes and technologies for particle separation to reduce the clogging and fouling of desalination systems. - Design novel membranes and technologies for removing dissolved salts and contaminants from seawater. - Demonstrate critical risk reduction for development of a hybrid energy storage system designed to maximize run time of DoD portable electronics through more efficient extraction of electrical energy from portable energy storage systems (batteries, fuel cells, etc.). - Develop a wide range of negative stiffness structural elements that can be incorporated at different levels in the structural frame of aircraft and high-speed maritime platforms in order to provide the optimum mechanical response to a given dynamic load.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Demonstrate ability to reconfigure hardware systems on surface wave control and power transmission materials. - Qualify carburized materials for unlimited naval use. - Design new membranes with high flux transport properties that are robust enough to double the lifetime over current membranes. - Demonstrate a portable seawater desalination system that provides thirty gallons per hour (gph) potable output from seawater using novel membranes and technologies while requiring significantly less energy and maintenance than current military systems. - Design novel membranes and technologies that will desalinate seawater at seventy five gph with twice the lifetime of existing desalination systems. - Proof of concept demonstrating feasibility of local control of chemistry for synthesis of customizable and adaptive surfaces and thin films with superior mechanical, electrical, optical, functional, etc. properties (example: diamond on temperature-sensitive surfaces such as polymers). - Demonstrate local control of chemistry for synthesis of customizable and adaptive surfaces and thin films with superior mechanical, electrical, optical, functional, etc. properties (example: diamond on temperature-sensitive surfaces such as polymers). - Prototype a hybrid energy storage system to maximize run time of DoD portable electronics through more efficient extraction of electrical energy from portable energy storage systems (batteries, fuel cells, etc.). - Engage DoD customers and commercialization partners for hybrid energy storage. - Develop new coatings, surface treatments, and multifunctional structures to extend lifetime and/or increase performance of materials (friction and wear, corrosion resistance, environmental capability, etc.) in critical DoD applications. - Complete developmental activities, including finite element modeling and shake table experiments, to validate the predicted performance of the negative stiffness structural elements for application to aircraft and high-speed maritime platforms.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiate the design of a structural sub-assembly that incorporates mechanical programs of tiered negative stiffness structural elements; activities include preliminary design and finite element modeling of the sub-assembly being used in the demonstration.					
Materials for Force Protection (U) The Materials for Force Protection thrust is developing novel materials and materials systems that will greatly enhance protection against ballistic, blast, and explosively formed projectile (EFP) threats across the full spectrum of warfighter environments. Included in this thrust are novel topological concepts as well as entirely new structural designs that will afford enhanced protection and functionality, at reduced weight and/or cost. *FY 2009 Accomplishments:* - Continued to develop lightweight armor systems to mitigate and defeat evolving threats, including EFPs. - Evaluated selected topological armor concepts for protection against multiple threats. - Demonstrated continued enhancement to transparent armor against fragmentation and armor piercing threats. - Integrated high performance armor systems with enhanced protection against evolving threats, including EFPs, into vehicle platforms in collaboration with the U.S. Army and Marine Corps. - Demonstrated performance of lightweight armor against explosively formed projectile threats. *FY 2010 Plans:* - Demonstrate production capability of index-matched fiber for transparent armor applications. - Develop glass/ceramic formulation and processing technologies to enable multi-hit performance of transparent armor equivalent to that of opaque armor. - Evaluate the effectiveness of high-strength materials with respect to stiffness, shock isolation, and energy absorption to establish the basis for improved armor performance against blast and fragment penetration to vehicle underbodies.	6.771	15.200	16.020	0.000	16.020

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Identify the most effective topological features for energy absorption and apply to optimize armor performance at a minimum system areal density against blast and fragment penetration to vehicle underbodies. *FY 2011 Base Plans:* - Demonstrate multi-hit performance of transparent armor equivalent to that of opaque armor. - Optimize the most promising composite designs and evaluate effectiveness for improved armor performance against blast and fragment penetration to vehicle underbodies with full-scale testing. - Develop a lightweight electromagnetic configuration that is powered by capturing kinetic energy from threat projectiles. - Through capturing kinetic energy, develop the capability to rapidly amplify power through magnetic flux compression by at least two orders of magnitude. - Initiate development of multi-functional material systems for vehicles that incorporate functionalities such as embedded antennas, sensors, and/or energy storage into vehicle structural and armor subsystems. - Develop new armor solutions that exploit unique high-strength/polymer composite/ceramic/glass hybrid configurations. - Begin to develop multifunctional passive and active hybrid systems concepts with efficient structural load support capabilities and protection within critical size, weight, and power constraints. - Develop corrugated and lattice truss core structures that can be flexed to desired geometries.					
Prognosis (U) The Prognosis thrust will demonstrate revolutionary, new concepts, physics-based models and advanced interrogation tools to assess damage evolution and predict future performance of the structural materials in defense platforms/systems. Included are demonstrations on Navy and Air Force aircraft structures, and engines for advanced jet aircraft and helicopters. Also included are sensor and model development required to support the damage prediction.	3.000	3.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Completed and provided a functional engine system prognosis (ESP) system applicable to the legacy (F100/F110) fleets that incorporates all physics-and data-driven models, exploits the available sensor packages, and incorporates all local and supervisory reasoners interfaced to the aircraft Digital Enhanced Engine Controller (DEEC)/Modern Digital Engine Controller (MDEC) for Oklahoma City Air Logistics Center (OC-ALC). - Transitioned to Original Equipment Manufacturers for incorporation in their engine designed and support tools. - Demonstrated ESP system on the T700 helicopter engines with specific objective of real time “power available” notification to the pilot. *FY 2010 Plans:* - Develop data mining tools for extracting key parameters from actual flight data and feed into damage models. - Evaluate P3 flight data and test Prognosis systems versus legacy method. - Demonstrate the capability to predict the performance, life, and reliability of the full P3 weapons system. - Identify rapid methods to optimize, qualify, and implement technologies into weapon systems of new materials. - Initiate study on damage accumulation mechanisms in composite structures. *FY 2011 Base Plans:* - Identify and validate damage models to metals other than aluminum and organic matrix components based on flight spectrum loading. - Establish probability of detection/probability of false alarm for applicable sensor suite. - Exploit the life-limiting, extreme-value probabilistic behavior of materials, structures, and processes in propulsion and aircraft systems.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Define protocol for global-local sensing technology and integration at a full systems level with state health information sufficient to prevent all future Class-A events and major aircraft down-time while assuring required combat capability. - Investigate processes and technologies for rapid certification and qualification of materials and structures that lead to reduced time to implementation. - Establish models that provide an adaptive tool that provides a “virtual twin” so that mission scenarios can be exercised and damage predicted.					
Materials for Initiation and Actuation (U) The Materials for Initiation and Actuation program explores and develops materials for initiation and propagation of mechanical and/or chemical effects. Included efforts are bio-inspired structures for meso-scale electrically initiated combustion, cyclic chemical reactions for communication, and high power, low volume, actuators required for high efficiency mobile platforms. *FY 2009 Accomplishments:* - Refined chemical communications systems to achieve 100-fold increase in transmission duration. - Demonstrated breadboard chemical communications devices consisting of a disposable transmitter and a replicator device that translate messages into chemistry. - Completed laboratory demonstration of flame suppression/manipulation using electric and acoustic fields. - Conducted rotor stand test of fully actuated one-third scale prop rotor to demonstrate blade synchronization and lift improvement. - Experimentally evaluated combustion driven nastic materials actuator for innovative acoustic applications. - Initiated design of material composites that are both high density and highly energetic. - Initiated development of processing methods to increase strength of dense reactive metal composite materials.	8.000	6.088	5.230	0.000	5.230

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Continue fundamental fire suppression investigations to understand scaling behavior and to determine best approaches for large scale system. - Perform fire suppression demonstration on a class A/B fire approximately 1 square meter in size. - Demonstrate the ability to achieve high density, high enthalpic energy, and high strength in the same material composite. - Demonstrate the ability to control particle size upon initiation and decomposition of reactive material. - Demonstrate the ability to ignite and combust reactive particles upon initiation and dispersion. - Develop integrated array sub-system of nastic materials acoustic sources and conduct experimental characterization of the array sub-system. - Complete preliminary design of acoustic demonstration system. *FY 2011 Base Plans:* - Demonstrate both structural and energetic function in a single material composite and the ability to produce multiple samples with specified properties in sizes greater that one half pound. - Demonstrate ability to command initiate energy release in a material composite that has the density of steel and a moderate (50 ksi tensile) strength. - Demonstrate blast performance from an explosive filled reactive case of at least twice that achievable with a similar explosive charge in an inert case.					
Reconfigurable Structures (U) In the Reconfigurable Structures thrust, new combinations of advanced materials, devices, and structural architectures are being developed to allow military platforms to morph or change shape for optimal adaptation to changing mission requirements and unpredictable environments. This includes the demonstration of new materials and devices that will enable the military to function more effectively in the urban theater of operations.	8.112	9.646	9.770	0.000	9.770

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Engineered soft components from the soft chemically-based materials that enable locomotion and size/shape morphing. - Engineered materials and soft components into robotic architecture with the ability to locomote, traverse openings smaller than the characteristic dimension of the robot, and reconstitute size/shape. - Designed, refined, and finalized reattachable pads (magnets and microspines) for hands and feet based upon results of biomechanical analysis and human climbing trials. - Demonstrated an unloaded soldier (150 lb) using reattachable pads (magnets and microspines) to scale a series of twenty-five foot walls built from mission-relevant materials. *FY 2010 Plans:* - Perform laboratory testing of engineered soft material robot operations and optimize design. - Perform laboratory demonstrations of robot function. - Develop engineering model for soft robots, and design prototype robots for selected applications. - Develop prototype robots for selected applications. - Demonstrate a fully loaded soldier (300 lb) wearing reattachable pads (magnetic and microspines) scaling a series of twenty-five foot walls built from mission- relevant materials using Z-MAN technology. - Demonstrate an unloaded soldier (150 lb) using reattachable pads (gecko nanoadhesives) to scale a series of twenty-five foot walls built from mission-relevant materials. *FY 2011 Base Plans:* - Perform laboratory demonstration of prototype soft material robots and refine designs. - Perform simulated field testing of prototype robots. - Finalize robot designs for field use. - Perform field testing of prototype robots and transition to end user. - Demonstrate a fully loaded soldier (300 lb) using reattachable pads (gecko nanoadhesives) to scale a series of twenty-five foot walls built from mission-relevant materials.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Transition Z-MAN prototype technologies to military services.					
Functional Materials and Devices (U) The goal of this thrust is to design material microstructures at the scale appropriate to exploit fundamental interactions with the environment in order to create materials with unique properties. Examples include nanostructured materials to slow light, negative refractive index systems, sensors that will enable room temperature sensitivity not currently available, and an array of other functional devices (antennas, dosimeters, etc.). *FY 2009 Accomplishments:* - Demonstrated a low loss, negative index enabled optical modulator with reduced size and increased speed for military communications. - Demonstrated a sub wavelength UHF antenna with enhanced efficiency for military radar and communication applications. - Demonstrated reconfigurable optical data buffer with tunable delay for 40 gigabits per second data packet of up to 500 nano-second with 25 pico-second reconfiguration time. - Devised slow light-based techniques for processing optical data headers. - Began synthesis of medium-wave infrared colloidal quantum dots. - Demonstrated nitrate detection ink. - Demonstrated peroxide detection ink. *FY 2010 Plans:* - Design broadband, frequency comb spectroscopy system with sensitivity better than ten parts per billion acetylene at 1.5 microns. - Evaluate performance improvements from, and system configuration changes needed to, shift comb central wavelength from 1.5 microns to 3 microns. - Demonstrate structural control methodology application to superconducting materials. - Demonstrate multiphoton excitation at short-wave infrared wavelengths.	4.871	5.000	7.500	0.000	7.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Demonstrate significant improvements in thermoelectric materials' figure of merit at cryogenic temperature ranges (100K-200K) for solid state refrigeration. - Demonstrate improved efficiency of infrared emitting materials. - Demonstrate modeling capabilities capable of predicting material performance. - Construct compact broadband, multipass optical cavity to enable signal multiplication at final system wavelength. - Design and construct compact broadband heterodyne detection system. - Demonstrate the detection system's spectral sensitivity better than 500 parts per trillion of acetylene in atmospheric pressure air in less than one minute.					
Power Components (U) This thrust explores and develops novel components for use in diverse power systems that will dramatically increase overall energy efficiency, typically with a substantial savings of weight/volume as well as cost. Included in this thrust are new permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors and generators, as well as high energy density capacitors. Radically new thermal electric architectures that allow for high efficiency in converting heat to electricity will be developed. Hybrid superconducting/cryogenic components will provide a new paradigm for power electronics for the "all electric" platforms of the future. Materials technology is also being developed to enhance power conditioning for large power applications such as Navy ships. *FY 2009 Accomplishments:* - Initiated scale-up from benchtop to an industrial manufacturer a capacitor that achieves 20 joules per cubic centimeter (J/cc) energy density and 100 joules (J) of energy. - Synthesized and electrochemically tested nanostructured and nanoparticulate lithium-based materials for use as the cathode material in an all solid-state battery.	6.000	8.700	8.650	0.000	8.650

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrated performance of thermoelectric materials optimized for use at specific temperature ranges. - Improved deposition techniques for thermoelectric materials resulting in 4 times greater figure of merit than previous results. - Engineered thermo-tunneling device structure for patterned gap supports and reduced die dimensions. *FY 2010 Plans:* - Integrate nanostructured thermoelectric materials into effective structure for military use. - Integrate nanostructured magnetic materials with high energy product into military motor. - Integrate nanostructured electrochemical materials with high energy and power densities into military battery supplies for the field. - Demonstrate packaged capacitors with 20 J/cc energy density and 100 J of energy. - Demonstrate nanogap thermo-tunneling device with an efficiency greater than 8 percent at a temperature difference of 200 degrees Celsius. *FY 2011 Base Plans:* - Demonstrate new nanocomposite magnetic materials with increased energy products for use in motors to better power both air and ground military vehicles. - Demonstrate innovative thermoelectric nanomaterials with improved power conversion efficiency to enable on-board powering of auxiliary electronics for aircraft and unmanned vehicles. - Integrate the 20 J/cc dielectrics into capacitors with sensing capabilities and fault tolerance to provide reliable high power capacitors of 20 J/cc and 400 J. - Begin to transition high energy dense capacitor technology to Air Force for improved weapons capabilities. - Demonstrate nanogap thermo-tunneling device with efficiency greater than 16 percent at a temperature difference of 350 degrees Celsius.					
Novel Power Sources	4.000	6.050	3.000	0.000	3.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Novel Power Sources thrust will explore new materials solutions that enable power to be efficiently generated and controlled. The primary focus is new catalytic materials and processes for alternative energy sources that are compatible with military logistic fuels. These include catalysts that affect JP-8, sunlight, and cellulose biomass. This thrust will also investigate technologies for tactical energy harvesting and/or generation. *FY 2009 Accomplishments:* - Developed extruded membrane within existing solid oxide fuel cell architecture to operate using JP-8 fuel. - Developed surface catalysts for cogeneration of carbon dioxide and hydrogen powered by sunlight. - Developed design strategies using catalysts for reducing carbon dioxide with sunlight, using JP-8 as fuel for fuel cells, and converting cellulosic biomass into an appropriate JP-8 precursor. *FY 2010 Plans:* - Continue catalyst development and initiate testing of catalysts powered by sunlight for reducing carbon dioxide and water into syngas (carbon monoxide and hydrogen). - Continue catalyst development and initiate testing of catalysts capable of quickly and efficiently converting cellulosic biomass into a synthetic fuel with eight carbons or more. - Identify and characterize new catalysts for highly efficient alternative energy systems including fuel cells, biomass conversion systems, and solar fuel systems. *FY 2011 Base Plans:* - Develop conceptual designs for revolutionary technologies for the portable harvesting and/or generation of energy at the tactical level. - Investigate physics of alternative wind energy extraction approaches.					
Very High Efficiency Solar Cell (VHESC)	20.129	4.800	2.000	0.000	2.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
(U) The Very High Efficiency Solar Cell (VHESC) program seeks to raise the system power efficiency of a new class of solar modules to forty percent and deliver engineering prototype modules that are producible. The modules use a novel optical system that splits light from the Sun into at least two different paths corresponding to the color of the light, and concentrates the light onto photovoltaic (PV) cells that cover different segments of the solar spectrum. System power efficiency includes all factors that impact the system (module) power efficiency, such as the transmission of light through the optics, as well as the individual efficiencies of the PV cells. Analysis predicts that fifty percent efficiency at the PV cell level yields a system power efficiency of at least forty percent. DARPA is developing the VHESC solar module technology for compact renewable energy to power both permanent and mobile bases, as well as to reduce the considerable logistical burden of supplying energy (e.g., batteries and fuel) to the warfighter in the field. (U) The program addresses all aspects of the high-efficiency photovoltaic problem including the development and analysis of high efficiency design concepts, the development of new and innovative components, materials, and processes necessary to achieve these concepts, and the development of scalable fabrication processes that are extensible to industrial manufacturing and an affordable product. Breakthrough results achieved in previous program phases including lateral architectures and non-imaging optical systems, high performance multi-band PV conversion, and ultra-low-cost PV materials fabrication processes have strongly narrowed the focus of the effort going forward. Future program phases will address both the technology development and manufacturing concept and engineering development necessary for the effective implementation of the VHESC technology in an affordable product. The key focus areas of future phases will be: 1) the system-integrated design optimization of the non-imaging lateral optics subsystem and the corresponding PV devices and 2) the development of high-volume cost-effective manufacturing engineering designs and processes for the subsequent future transition to affordable production. *FY 2009 Accomplishments:* - Designed, built, and tested VHESC engineering prototype modules addressing the program goals.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Developed technologies to reduce the costs of the PV cells and optical components. *FY 2010 Plans:* - Deliver an initial integrated prototype. - Conduct demonstration necessary for the effective implementation of the VHESC technology in an affordable product. *FY 2011 Base Plans:* - Evaluate further development and improvements in solar cell technology for future DoD applications.					
Alternate Power Sources (U) The Alternate Power Sources thrust aims to develop materials and technologies to utilize alternative power sources that have the potential to provide significant strategic and tactical advantages to the DoD. A consistent DoD need continues to be greater efficiency in a portable form factor. Portable photovoltaic technologies will strive to meet this need and with low cost manufacturing. Very small volume (less than one cubic millimeter) rechargeable micro-batteries with maintained energy density comparable to conventional lithium ion batteries are being developed. This thrust also looks at alternative portable energy storage and/or power distribution and control technologies. *FY 2009 Accomplishments:* - Further improved polymer/ceramic composite sealing and photovoltaic performance in thin film packaged batteries that possess energy densities greater than 200 watt hours per liter (Wh/L) in a volume of less than 1 cubic millimeter. - Developed packaging protocol to produce large arrays of electrochemically inert, gold packaged lithium ion microbatteries.	2.500	7.500	15.500	0.000	15.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Increase the reliability and manufacturing yield of packaged batteries with energy densities greater than 350 Wh/L in a volume less than 1 cubic millimeter. - Explore the light acquisition, energy capture, and carrier extraction aspects of portable photovoltaic (PV) devices to identify most advantageous breakthroughs to exploit these devices. - Explore the robust and durable portability, and flexibility aspects of portable PV devices to identify most advantageous breakthroughs to exploit these devices. - Develop conceptual designs for revolutionary technologies for portable energy storage and/or power distribution and control technologies at the tactical level. *FY 2011 Base Plans:* - Create new portable photovoltaic (PV) technologies that function at greater than or equal to 16 percent power conversion efficiency (under AM1.5 illumination at one sun) in a form factor amenable to flexible substrates. - Develop new portable PV technologies that allow for low cost manufacturing. - Develop new portable PV technologies that allow for backpack portable PV devices. - Establish proof-of-concept for tactical energy storage and/or power distribution and control technologies. - Initiate development of tactical energy generating storage and/or power distribution and control technology prototypes.					
Biofuels (U) The Biofuels program is exploring longer term, higher risk approaches to obtaining and using energy. A pathway to affordable self-sustainable agriculture-sourced production of an alternative to petroleum-derived JP-8 that will meet all DoD needs will be investigated. Initial efforts are focused on the conversion of crop oil triglycerides to JP-8. Additional efforts will expand the spectrum of convertible feedstocks to cellulosic, algal, and other similar materials, enabling a diversified feedstock	13.500	23.900	32.948	0.000	32.948

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
portfolio that can meet the entire DoD need within a sustainable commercial framework. An important variant of this latter category is the development of man- and vehicle-portable technologies to produce substantial quantities of JP-8 and other useful liquid fuels from indigenously available or harvestable resources near desired locations worldwide. *FY 2009 Accomplishments:* - Identified and selected technology pathways for the development of man- and vehicle-portable systems capable of producing JP-8 and other useful liquid fuels from a broad diversity of feedstocks. - Demonstrated the conversion of cellulosic materials to JP-8 range alkanes with greater than thirty percent efficiency (by energy). - Identified a pathway for the conversion of cellulosic materials to JP-8 range alkanes with greater than fifty percent efficiency (by energy). - Identified multiple pathways for conversion of algal oils to JP-8 range alkanes at a cost of less than two dollars of triglyceride oil per gallon. - Identified one pathway for the conversion of algal oils to JP-8 range alkanes at a cost of less than one dollar triglyceride oil per gallon. - Explored the size and volume efficiency scaling relationships for various processing technologies for converting indigenous materials to JP-8 and other liquid fuels. - Developed preliminary designs for vehicle-portable and man-portable liquid fuel production systems. *FY 2010 Plans:* - Develop a qualification plan that specifies a path to support the full DoD qualification of the developed BioFuel as an acceptable alternative to JP-8. - Perform fleet-test of Biodiesel 25 with twenty-five percent hydrocarbon base to demonstrate possibilities of 100 percent biological jet fuel with hydrocarbon base. *FY 2011 Base Plans:* - Demonstrate system scale up to 4000 liters per month capacity and validate cost goal.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Evaluate sensitivity of biofuel cost of production in multiple locations. - Establish commercialization path to include production, co-product application, and transition to DoD program of record.					
Universal Batteries (U) The goal of this program is to develop adaptable and highly efficient primary batteries with a path toward future rechargeable versions. The basic concept is to include control electronics within the battery housing that will allow the voltage to be set to suit particular needs and to provide external physical adapters to allow batteries to be fit into end-use systems. Another key development area is sufficiently miniaturized power management circuitry that could be integrated into compact battery packages such as the common AA, C and D cells, providing access to the "leftover" charge capacity in these cells which is normally discarded due to voltage droop. *FY 2011 Base Plans:* - Analyze key primary battery needs, design appropriate power management circuitry and fabricate prototype battery units. - Create and demonstrate development path, including compact switch-mode energy storage elements, for miniaturized, mass-production capable power conversion/management modules that could be integrated into compact battery formats.	0.000	0.000	10.000	0.000	10.000
Long Duration Power Concepts (U) The requirement for generating power over long duration missions proposes unique challenges in energy storage, power conditioning and overall integration. This thrust explored the breakthroughs in power generation needed for extremely long duration, unmanned applications including unmanned underwater vehicles (UUVs). These included energy storage approaches that are efficient as well as energy efficient. It also evaluated approaches for efficiently removing the energy at rates commensurate with the high sprint power often required in these applications.	1.371	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Conducted a full scale laboratory demonstration of solid oxide fuel cell/battery power system for a thirty day large scale UUV mission.					
Accomplishments/Planned Programs Subtotals	109.321	131.882	175.586	0.000	175.586

	FY 2009	FY 2010
Congressional Add: Strategic Materials *FY 2009 Accomplishments:* - Continued chemical vapor composited (CVC) silicon carbide (SiC) process development. - Demonstrated bonding and integration of CVC SiC assemblies. *FY 2010 Plans:* - Continue research into promising areas of strategic materials.	4.400	5.000
Congressional Add: Synthetic Fuel Innovation *FY 2009 Accomplishments:* - Researched innovative techniques for the development of synthetic fuels.	4.000	0.000
Congressional Add: Center for Nonproliferation Studies, Monterey Institute for International Affairs *FY 2010 Plans:* - Initiate research of nonproliferation studies.	0.000	1.600
	0.000	2.880

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Photovoltaic Ribbon Solar Cell Technology Project *FY 2010 Plans:* - Conduct research into photovoltaic ribbon solar cell technology.		
Congressional Adds Subtotals	8.400	9.480

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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	120.451	128.845	137.000	0.000	137.000	120.000	120.000	120.000	120.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project acknowledges the growing and pervasive influence of the biological sciences on the development of new DoD capabilities. This influence extends throughout the development of new materials, devices and processes, and relies on the integration of biological breakthroughs with those in engineering and the physical sciences. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the use of biology's unique fabrication capabilities to produce structures that cannot be made any other way, the application of materials in biological applications, and the development of manufacturing tools that use biological components and processes for materials synthesis. This project also includes major efforts aimed at integrating biological and digital sensing methodologies and maintaining human combat performance despite the extraordinary stressors of combat. Finally, this thrust will develop new diagnostics, therapeutics, and procedures to save lives on the battlefield, as well as restore full functional capabilities to combat amputees by developing a revolutionary upper limb prosthetic device.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
BioRobotics and BioMechanics (U) The BioRobotics and BioMechanics thrust explores approaches to capture biological systems' ability to move and sense, and emulate them in man-made robotic or sensor systems. The effort includes providing robotics with the mobility required to provide support to soldiers in all terrains, including climbing. *FY 2009 Accomplishments:* - Studied adaptive materials and controlled devices for biped locomotion. - Developed algorithms for robotic arm control.	1.000	1.500	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Investigate capability to actuate over efficiently large displacement at frequencies exceeding ten hertz.					
Bioderived Materials (U) The Bioderived Materials thrust explores the use of biological and bioinspired materials to support diverse Defense missions and/or technologies that enhance the capabilities of U.S. military systems. Areas of interest include designing and developing biomolecular materials that have unique electrical and mechanical properties; new bioinspired processing routes for dynamic self-assembly of complex functional structures, including biomanufacturing; and adapting the ability of biological systems to manipulate light and texture. *FY 2009 Accomplishments:* - Investigated new methods of biotemplating and biocatalysis with biological materials (i.e., microtubules, filamentous viruses, peptides, bacteriophages) to facilitate new sensors and devices. - Studied novel surfaces that have tunable properties, e.g., texture, hydrophobicity, optical reflectance/ transmission, and absorption. *FY 2010 Plans:* - Characterize the electronic and optoelectronic properties of novel biomaterials to develop high performance sensors and devices with new and unique capabilities. - Exploit unique structures found in biological systems that could enable new multifunctional materials. *FY 2011 Base Plans:* - Develop inexpensive processing techniques at ambient conditions for hybrid inorganic-organic structures with customized programmable biotemplates to create high performance sensors and devices with new and unique capabilities. - Demonstrate biotemplate membranes capable of energy harvesting at 15 percent greater efficiency.	1.000	2.000	3.700	0.000	3.700

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate bio-inspired infrared imaging device at 128 x 128 pixel resolution.					
Bioinspired Sensors	12.900	18.300	3.000	0.000	3.000

(U) The Bioinspired Sensors thrust explores the application of biomimetic principles to materials and devices of interest to the DoD. Specifically, the unique characteristics of biologically derived material and devices will be exploited through understanding, control and emulation of the structure and chemistry of the interface between man-made and biotic materials. This includes an effort to understand the mammalian olfactory system and develop a system that performs equal to or better than a canine in distance and level of chemical detection. Biological hearing systems also provide localization accuracy much better than predicted by simple array theory. Development of implantable optical neural interface devices will enable "repair" of disrupted neural pathways due to catastrophic spinal or nerve damage.

FY 2009 Accomplishments:
- Developed breadboard olfactory system, with emphasis on chip-based, non-cellular expression approaches for detection of relevant odorant molecules.
- Demonstrated rapid detection of defined odorant molecules through the olfactory receptor-based breadboard system.
- Developed methods for rapid synthesis of odorant receptors not previously expressed in the olfactory breadboard system.
- Completed a design review of breadboard olfaction systems; conducted test and evaluation of all approaches simultaneously at an independent testbed.

FY 2010 Plans:
- Develop brassboard olfactory system(s) based on successful previous designs.
- Demonstrate the olfactory brassboard’s ability to detect twenty-five individual odorants/chemicals, with a portion contained in a chemical mixture.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate detection and identification of odorants at a probability of detection greater than or equal to ninety percent. - Determine relative concentration of individual odorant(s) in mixture. *FY 2011 Base Plans:* - Complete design finalization for olfactory brassboard system prototype. - Transition technology to DoD partner.					
Maintaining Combat Performance (U) The Maintaining Combat Performance thrust utilizes breakthroughs in biology and physiology to sustain the peak physical and cognitive performance of warfighters operating in extreme conditions. Today, warfighters must accomplish their missions despite extraordinary physiologic stress. Examples of these stressors include extremes of temperature (-20 degrees F to 125 degrees F), oxygen deficiency in mountains, personal loads in excess of 100 lbs, dehydration, psychological stress, and even performance of life-sustaining maneuvers following combat injury. Not only must troops maintain optimum physical performance, but also peak cognitive performance, which includes the entire spectrum from personal navigation and target recognition, to complex command and control decisions, and intelligence synthesis. The Maintaining Combat Performance thrust leverages breakthroughs in diverse scientific fields in order to mitigate the effects of harsh combat environments. For example, understanding the natural mechanisms for core body temperature regulation in hibernating mammals has led to a novel, practical approach for soldier cooling, which is now being evaluated by troops in the far forward combat areas. Other examples include fundamental research elucidating the biological mechanisms of adaptation to extreme altitude, and the molecular correlates of muscle fatigue and psychological stress. *FY 2009 Accomplishments:* - Identified mechanisms to alleviate high altitude illness.	6.463	12.100	13.300	0.000	13.300

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Identified the following for high altitude illness: mechanisms to increase pulmonary blood flow; methods to increase number of red blood cells; and mechanisms to increase oxygen delivery to muscles. *FY 2010 Plans:* - Investigate mechanisms to speed natural acclimatization at high altitudes. - Develop strategies based on identified mechanisms to accelerate natural altitude acclimatization from 4 weeks to 48 hrs. - Determine pharmacological markers to alleviate high altitude illness. - Develop field-deployable drug that includes minimal training requirements and minimal demands on supporting infrastructure for optimal battlefield use. - Analyze efficiency, toxicity, and pharmacokinetic information from in vivo swine testing to prepare Investigational New Drug (IND) application for use in an FDA Phase I clinical trial. *FY 2011 Base Plans:* - Complete a limited FDA Phase I clinical trial for pharmacokinetics, surrogate-efficiency markers, and tolerance in healthy adults ages 18-24 (n=20 minimum) to determine drug safety. - Complete dosing requirements and efficacy demonstration for initiation of an FDA Phase II clinical trial.					
Cognitive Technology Threat Warning System (CT2WS) (U) Recent advances in computational and neural sciences indicate it is possible to push the visual threat detection envelope to enable more response choices for our soldiers than ever before. The objective of the Cognitive Technology Threat Warning System (CT2WS) program is to drive a breakthrough in soldier-portable visual threat warning devices by leveraging discoveries in the disparate technology areas of flat-field, wide-angle optics, large pixel-count digital imagers, visual processing pathways, neurally based target detection signatures and ultra-low power analog-digital hybrid signal processing electronics. This program will lead to the development of prototype soldier-portable digital	16.000	13.800	11.700	0.000	11.700

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
imaging threat queuing systems capable of effective detection ranges of 1-10 km against dismounts and vehicles. Simultaneously, the system will survey a 120-degree or greater field of view, enabling the warfighter to detect, decide and act on the most advantageous timeline in complex operational environments. *FY 2009 Accomplishments:* - Demonstrated single path (twenty degree by twenty degree) advanced optics on a breadboard system in a field environment consistent with objective performance and package volume. - Demonstrated human-in-the-loop integration with the breadboard system, harnessing non-invasive neural signatures for threat detection. - Demonstrated visual/cognitive algorithm performance for threat detection on operationally significant image streams with probability of detection (greater than .98) and false alarm rates (less than ten) in less than sixty seconds of scan time. - Demonstrated composite software system capable of high fidelity threat detection with extremely low false alarm rates. - Tested breadboard performance during week-long operational test at Yuma Proving Ground, AZ. *FY 2010 Plans:* - Develop integrated brassboard designs consistent with desired threat cueing performance. - Increase field of view to 120 degrees x twenty degrees while maintaining size, weight and power constraints. - Demonstrate visual/cognitive algorithm performance for threat detection on operationally significant image streams with probability of detection (greater than .98) and false alarm rates (less than ten) in less than thirty seconds of scan time. - Complete critical design review of bench-integrated prototype system evaluations that demonstrate the capability of the design to meet the objective system program performance. - Evaluate device packaging approaches with the knowledge of ruggedization and robustness required for soldier-portable tactical electronic devices.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Complete final optimization of the brassboard components and subsystems. *FY 2011 Base Plans:* - Conduct mid-phase Test Readiness Review (TRR) to validate both the maintenance of the performance efficacy previously demonstrated and suitable device ruggedization to support extended field testing. - Conduct extended field testing over a six-month period. The in-the-field performance of the devices shall be analyzed for efficacy and potential improvements. - Integrate and package three or more fully functional prototype systems for subsequent extended field testing in a range of real environments including desert and tropical conditions. - Execute a Memorandum of Agreement with Service transition partner(s) for test and evaluation.					
Neovision2 (U) Biological vision systems have the exquisite ability to recognize, categorize, and learn new objects in fractions of a second. While animals and humans accomplish this seemingly effortlessly and constantly, computational vision systems have, to date, been unable to replicate this feat of biology. The Neovision2 program is pursuing an integrated approach to developing an advanced object recognition capability based on the visual pathways in the mammalian brain. Specifically, this program will develop a cognitive sensor technology with limited size, weight, and power that transforms data from an imaging sensor suite into communicable knowledge for mobile, autonomous surveillance systems. To achieve the vision, the program will utilize advanced device design, signal processing and mathematical techniques across multiple brain regions to revolutionize the field and create an electronic neuro-biological (neuromorphic) vision system. *FY 2009 Accomplishments:* - Created neuromorphic floating point gate array (FPGA) emulation for use as a tool to test advanced algorithms developed by vision research community. - Designed novel integrated circuit design for the replication of specific visual pathway functions.	9.000	10.868	12.500	0.000	12.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Fabricated and completed functional test of a neuromorphic FPGA for emulation of basic mammalian visual pathway functionalities. *FY 2010 Plans:* - Design next generation neuromorphic vision system capable of emulating entire mammalian visual pathway, through object recognition. - Fabricate breadboard neuromorphic object recognition system(s) with enhanced visual function capabilities beyond state of the art. - Test new neuromorphic object recognition system(s) against desired visual pathway performance, including probability of detection >90 percent, >10 object categories and recognition within 5 seconds. - Evaluate device packaging approaches with the knowledge of ruggedization and robustness required for robotic and airborne unmanned systems. *FY 2011 Base Plans:* - Incorporate further refinements and developments of visual pathway algorithms and neuromorphic hardware into current design(s). - Develop brassboard neuromorphic vision system(s) inclusive of retinal input to subsequent output. - Fabricate brassboard neuromorphic object recognition system(s) with size, weight and power cognizant of constraints for unmanned systems. - Demonstrate saccade, foveation, and object recognition with visual inputs, neuromorphic processing and outputs in real time, less than 2 seconds to recognition. - Conduct extensive testing for object recognition performance with probability of detection >95 percent, greater than 20 object categories with an imaging range of 4 kilometers; evaluate as compared to standard target recognition systems currently in use.					
Tactical Biomedical Technologies (U) The Tactical Biomedical Technologies thrust will develop new approaches to deliver life-saving medical care on the battlefield, as well as novel technologies for reconstruction and rehabilitation of	11.700	15.777	19.600	0.000	19.600

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**PROJECT** MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
severely injured warfighters. Implicit in this thrust is the fact that there are unique, warfighter-specific challenges in acute and chronic treatment that are not addressed by civilian research and development. Today, more than half of American battlefield fatalities are due to hemorrhage, particularly due to improvised explosive devices (IEDs). To prevent these deaths, there is an urgent need for technologies that enable relatively unskilled personnel (battlefield medics) to diagnose and treat injuries, including the ability to locate and coagulate non-compressible deep bleeders in the thorax or abdomen. Other critical needs stem from the fact that warfighters are frequently victims of blasts, causing patterns of brain, burn, and orthopedic injuries not seen in civilian medical practice. As such, there is a unique military need to develop systems for pain control that are safe even in medically unmonitored environments, such as an active battlefield. Once lives are saved, there is an unmet need for new methods to restore function, for example, by restoring long segments of bone that were lost due to blast fragmentation. The results of this program will greatly enhance our ability to save lives on the battlefield and provide restoration of normal function to survivors. *FY 2009 Accomplishments:* - Demonstrated extended survival time using an FDA-approved estrogen product after 60% total blood volume loss in swine hemorrhage model. - Developed a physiological-based pharmacokinetic/pharmacodynamic model of the cardiovascular system to aid in determining appropriate estrogen doses in humans suffering lethal hemorrhage. - Demonstrated blastemal associated initiation of early joint formation at appropriate site during healing. - The Deep Bleeder Acoustic Coagulation (DBAC) program is currently developing a portable, non-invasive, automated system for the detection, localization, and coagulation of deep bleeders that is operable in the combat environment by minimally trained personnel. The stationary wrap-around device must prove to be lightweight and operate on batteries. To this end, one therapy module and one detection and localization (D&L) module with weight commensurate to meet a full 40 x 80 cm cuff weight of less than or equal to 4.8 kg was successfully designed and built.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Conducted in vivo and in vitro experiments to determine the effect of physiological variables on the DBAC algorithm. - Developed and tested automated algorithms for bleeder detection, localization, coagulation, and cuff control and integrated into a 2.4 kg prototype cuff. - Identified two materials capable of infiltrating into both penetrating noncompressible wounds and surface wounds for potential use in new wound-healing technology. - Determined specific wound biomarkers for targeting hemostatic (stops bleeding) materials. *FY 2010 Plans:* - Demonstrate in vivo induction of restorative skeletal muscle repair by transplant of induced pluripotent cells. - Determine transition kinetics from joint formation to bone morphogenic protein-2 (BMP-2)-induced long bone restoration. - Develop a material that can be delivered to a closed, intracavity space and binds specifically to damaged tissue as demonstrated in situ by immunohistology. - Demonstrate that hemostatic material does not induce intracavity scar formation within 28 days when left at the wound site. - Build and demonstrate an automated laboratory prototype DBAC system. - Optimize automated algorithms for bleeder detection, localization, coagulation, and cuff control with in vivo models. *FY 2011 Base Plans:* - Demonstrate compatibility with FDA-approved agents that control pain, infection, and inflammation. - Achieve wound treatment system unit specs including coverage of at least 0.20 square meters of tissue area, mass of less than 200 grams, and a volume less than 150 ml. - Demonstrate hemostasis in less than four minutes on a high-pressure non-compressible injury model. - Maintain hemostasis in high pressure model for three hours.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate DBAC system is capable of detecting and localizing clinically significant bleeder sizes, tracking the movement of the site based on tissue and patient movement, coagulating the bleeder, and determining completion of coagulation without a human decision maker in the loop. - Initiate development of an advanced computational fluid-structures interaction capability than can accurately simulate shock/blast interaction with the cranium, couple this energy with brain tissue, and account for shock wave dispersion, coalescence, and localization at specific locations within the brain. - Initiate development of an experimental capability to validate the fluid dynamics, materials, and mechanics components of the computational capability to determine biological damage and begin to correlate these results with neurological observations. - Demonstrate capability to manufacture a set of commonly-used organic pharmaceuticals in a small form-factor device while maintaining comparable mass efficiency to shelf-stable products. - Investigate potential for chemical modification of pharmaceuticals and therapeutics in order to stabilize compounds that are otherwise unstable at room temperature.					
Trauma Pod (U) The Trauma Pod program evaluated new approaches to deliver life-saving medical care on the battlefield. The effort explored innovative procedure modules, imaging and surgical techniques, and a portable tactical platform that could allow patient stabilization and provide precious additional time for transport to the combat support hospital. *FY 2009 Accomplishments:* - Conducted needs assessment study on technology gaps among in-theater medical providers and identified immediate need for portable imaging technologies capable of detecting high-risk injuries such as pneumothorax and closed head injury.	2.000	0.000	0.000	0.000	0.000
Biological Interfaces (U) This thrust area explores and develops biological interfaces between biotic and abiotic materials. Examples include infection prevention/sterilization at the interface between skin and a battlefield	2.900	3.500	3.000	0.000	3.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
medical device (such as a central intravenous catheter) as well as enhancing the rehabilitation/recovery effectiveness of interfaces between bone and orthopedic stabilization devices. *FY 2009 Accomplishments:* - Investigated bacterial and spore population reduction using plasma in non-uniform substrates. - Initiated studies of plasma dose required for million-fold reduction in bacterial population in animal wound model. *FY 2010 Plans:* - Complete studies of plasma dose required for million-fold reduction in bacterial population for porcine wound model. - Develop and perform safety studies to determine effects of plasma dose on mammalian cells. - Perform in vitro studies of plasma effects on viral pathogens. - Design plasma-based bandage for wound treatment based on safety studies and dose response curves from animal wound models. *FY 2011 Base Plans:* - Design self-sterilizing catheter incorporating plasma-based sterilization of catheter insertion point and interior catheter surface. - Design appropriate test procedure to evaluate treatment efficacy of plasma-based bandage and/or self-sterilizing plasma catheter for wound treatment based on dose response curves from animal wound models. - Perform in vivo animal wound studies to determine efficacy of plasmas for sterilizing viral wound pathogens.					
Neuroscience Technologies (U) The Neuroscience Technologies thrust leverages recent advances in neurophysiology, neuro-imaging, cognitive science and molecular biology to sustain and protect the cognitive functioning of	17.800	16.700	16.000	0.000	16.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
the warfighter faced with challenging operational conditions. Warfighters experience a wide variety of operational stressors, both mental and physical, that degrade critical cognitive functions such as memory, learning, and decision making. These stressors also degrade the war fighter's ability to multitask, leading to decreased ability to respond quickly and effectively. Currently, the long-term impact of these stressors on the brain is unknown, both at the molecular and behavioral level. This thrust area will utilize modern neuroscientific techniques, in conjunction with emerging solutions in neurally enabled human-machine interface technologies, to develop quantitative models of this impact and explore mechanisms to protect, maintain, complement, or restore cognitive functioning during and after exposure to operational stressors. For example, new approaches for using neural signals to make human-machine systems more time efficient and less workload intense will also be identified, developed, and evaluated. This project will also investigate the integration of recently-characterized properties of human brain function and real-time signal processing to enable rapid triage of target-containing imagery. This thrust area will have far-reaching implications for both current and future military operations, with the potential to protect warfighter cognitive performance both prior to and during deployment. *FY 2009 Accomplishments:* - Demonstrated two-fold improvement on specific military learning tasks utilizing neuroscience-based accelerated learning techniques. - Investigated task-independent methods for accelerating learning, including improvements to working memory, attention, and engagement. - Confirmed the stability of neural signatures in complex imagery conditions, including imagery sources and target types. - Completed controlled operational tests to demonstrate utility of neural signatures in imagery analysis environment to motivate potential transition interest. - Demonstrated applicability of neural signature-based triage for specific analyst derived concept of operations including broad area search.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop a comprehensive quantitative description of the impact stress has on the brain and leverage cutting-edge technologies and recent advances in molecular neurobiology, neuroimaging and molecular pathway modeling as applied to animal models of acute and chronic stress. - Identify and characterize the genetic and molecular targets behind the adaptive vs. dysfunctional response to stress, exploring a minimum of four stressors (cognitive, physical, social sleep deprivation, illness, etc). - Develop training applications to implement the acceleration methodologies for specific Army, Navy, and Air Force operational tasks. - Implement task-independent methods for accelerating learning to existing training paradigms within the Services. - Demonstrate significant increase in imagery throughput and analytic product generation on specific operational tasks in the authentic imagery analysis environment. - Develop prototype systems that utilize neural signatures to speed analysis and improve quality and accuracy of imagery exploitation. - Initiate transition of technologies and methodologies to operational use including access to classified imagery, while validating utility of neural signature inputs into imagery workflow. - Characterize the underlying neural processes of three or more components of cognition. - Demonstrate correspondence between neural processes and each cognitive component. - Establish temporal sequencing of cognitive components. *FY 2011 Base Plans:* - Establish a fast, functionally relevant, brain-based measurement of the current state of the stress response system that captures the basic features of physiological responses associated with changes in acute and chronic stress state. - Utilize predictive modeling to determine which genetic and molecular targets are optimal for adaptive vs. dysfunctional responses to stress.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Establish an in vivo anatomical and molecular pathway that causes stress related dysfunction in an animal model and identify three targets for modulation. - Demonstrate that modulation of the identified and validated targets/pathways improves stress-induced cognitive dysfunction in a minimum of 75% of animals as measured by molecular markers and resulting behavior. - Design pharmacological, behavioral or other interventions for prevention of stress-induced cognitive dysfunction based on observations. - Demonstrate improved cognitive model performance using neural representations of cognition. - Demonstrate improvement in cognitive model performance compared to non-neural approach on at least one task to which previously identified cognitive components contribute. - Show improvement in cognitive model ability to predict individual's cognitive behavior in at least two different, never-before-encountered, tasks and task environments.					
Military Medical Imaging (U) The Military Medical Imaging thrust will develop medical imaging capabilities to support military missions and operations. Examples include novel technologies to miniaturize and enhance the capabilities and speed of computerized axial tomography (CAT) scanners and to develop non-invasive imaging modalities for use by medics. The emergence of advanced medical imaging includes newly recognized physical properties of biological tissue, or metabolic pathway, or physiological function in order to map it into an image of diagnostic utility and performance. This need is ever increasing as researchers and scientists seek to better understand anatomical, functional and cellular level interactions. This thrust will also address how to improve the delivery of medical care and medical personnel protection by building a simulated environment for rapid after-action review of field events generated from current military systems. The advanced development of these tools will provide a formidable arsenal of diagnostic tools for warfighter performance and care.	4.000	8.000	8.100	0.000	8.100

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Investigated rapid mission rehearsal thrust technologies and explored capability to augment simulation platforms with advanced physics and physiologic modeling. - Identified DoD agencies that acquire data on medical outcomes, materiel damage, and mission briefings in order to incorporate that information into simulation platforms for after-action forensic reconstruction. *FY 2010 Plans:* - Incorporate rapid mission rehearsal thrust technologies with computer-aided forensic methods into after-action review to aid in reconstructing incidents from existing data. - Utilize reconstructed scenarios for assessment of “lessons learned” and to gain immediate and relevant tactical battlefield knowledge. - Demonstrate that an incident can be fully reverted to initial conditions using only injury and vehicle data. - Attempt to determine directionality, cause, and type of non-lethal injuries to individuals and insults to vehicles from in-theater data, improving responsiveness to threats on the battlefield as new threats emerge. - Simulate elements of data collected from battlefield through existing RealWorld simulation platform to investigate how this software’s unique capabilities can be fully exploited for an after-action simulated environment. - Demonstrate geographic tracking of disparate events in physical and temporal space. *FY 2011 Base Plans:* - Manufacture sensors as needed to fill in capability gaps with existing sensor suites. - Enable near-real time capability to determine cause and type of insult to vehicular armor. - Integrate all databases with data fusion engine appended onto RealWorld simulation platform. - Demonstrate ability to automatically detect, track, and analyze similar events and incidents in temporal and physical space.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Focus X-rays with orbital angular momentum through a model of skin and bone. - Develop X-ray optics for scanning.					
Revolutionizing Prosthetics	24.800	15.000	12.000	0.000	12.000
(U) The goal of this thrust is to radically improve the state of the art for upper limb prosthetics, moving them from crude devices with minimal capabilities to fully integrated, fully functional limb replacements. Current prosthetic technology generally provides only gross motor functions, with very crude approaches to control. This makes it difficult for wounded soldiers to return to military service. The advances required to provide fully functional limb replacements will be achieved by an aggressive, milestone driven program combining the talents of scientists from diverse areas including: medicine, neuroscience, orthopedics, engineering, materials science, control and information theory, mathematics, power, manufacturing, rehabilitation, psychology and training. The results of this program will radically improve the ability of combat amputees to return to normal function. *FY 2009 Accomplishments:* - Integrated sensory feedback into prosthetic devices. - Evaluated sensory feedback in patients with targeted neural re-implantation. - Completed design of chip for transmission of central nervous system motor signals. - Evaluated chip in experimental models. *FY 2010 Plans:* - Develop clinical protocol for testing of four-year prosthetic devices at military medical centers. - Initiate manufacture plan consistent with Good Manufacturing Practices (GMP). - Complete clinical and take home trials supporting FDA submission criteria. - Support experiments to determine potential level of direct neural control for upper-extremity prosthetic. - Finalize mechanical arm design and ensure readiness for wide-scale manufacture and production.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete qualification testing and demonstrations of central and peripheral multimodal neural interfaces suitable for submission to FDA. - Finalize and submit complete FDA package to obtain approval for commercial production of arms and sockets. - Support transition efforts of final limb, components and refinements required by the FDA.					
Biodemilitarization of Munitions (U) Based on results from the External Protection Program in PE 0602383E, Project BW-01, the Biodemilitarization of Munitions program evaluated a system for rapid, safe, and effective inactivation of explosive munitions stockpiles in place. Chemical and biological technologies and control processes were developed to alter the explosive fill and enable long-term storage and high-reliability inertion of munitions. *FY 2009 Accomplishments:* - Designed, developed, and tested solid-state transformation processes. - Conducted a Preliminary Design Review for a demonstration system. - Conducted sensitivity testing to determine intermediate and final inertion products to include yield testing in chamber.	3.442	0.000	0.000	0.000	0.000
Blood Pharming (U) The overall Blood Pharming program objective is to develop an automated culture and packaging system that yields transfusable levels of universal donor red blood cells (RBCs) from progenitor cell sources. The goal of the Phase II effort is to produce 100 units of universal donor (Type O negative) RBCs per week for eight weeks in an automated closed culture system using a renewing progenitor population. Central to Phase II work will be the demonstration of a two hundred million-fold expansion of progenitor cell populations to mature RBCs. To realize these goals, Phase II will capitalize advances	7.446	5.300	4.100	0.000	4.100

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
in cell differentiation, expansion, and bioreactor technology developed in Phase I of the program. Successful completion of the Blood Pharming effort will provide a safe donorless blood supply that is the functional equivalent of fresh donor cells, satisfying a large battlefield demand and reducing the logistical burden of donated blood in theater. Phase I was completed in PE 0601101E, Project BLS-01, Biological Adaptation, Assembly and Manufacturing Program. *FY 2009 Accomplishments:* - Demonstrated greater than or equal to two million-fold expansion from progenitor source to mature RBC. - Demonstrated characteristic functions of RBC (oxygen binding/release, enzyme content, size, deformability) in vitro. - Developed strategies for production of ten RBC units per week for four weeks in an automated closed culture system using a non-renewing (replaceable) progenitor cell population. *FY 2010 Plans:* - Demonstrate production of 10 RBC units per week for four weeks in an automated closed culture system using a renewable progenitor cell population. - Demonstrate one billion-fold expansion of progenitor population to mature RBCs. - Demonstrate magnetic isolation of mature enucleated RBCs at a rate greater than one million cells per second. *FY 2011 Base Plans:* - Demonstrate immunogenicity of bioreactor-developed RBCs in an in vivo model. - Demonstrate efficacy of bioreactor-developed RBCs as a transfusion product in an in vivo trauma model.					
BioDesign	0.000	0.000	6.000	0.000	6.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) BioDesign is a new intellectual approach to biological functionality. The intrinsic concept is that by using gained knowledge of biological processes in combination with biotechnology and synthetic chemical technology, humans can employ system engineering methods to originate novel beneficial processes. BioDesign eliminates the randomness of natural evolutionary advancement primarily by advanced genetic engineering and molecular biology technologies to produce the intended biological effect. This thrust area includes designed molecular responses that increase resistance to cellular death signals and improved computational methods for prediction of function based solely on sequence and structure of proteins produced by synthetic biological systems. Development of technologies to genetically tag and/or lock synthesized molecules would provide methods for identifying the origin and source of synthetic biologicals (e.g., genes or proteins) allowing for traceability and prevention of manipulation ("tamper proof" synthetic biological). *FY 2011 Base Plans:* - Demonstrate computation protein conformation algorithms that model one residue per minute with 99.5% accuracy for every one kilodalton of mass regardless of protein class. - Develop conformation prediction algorithms for biomimetic polymers and biological-nonbiological hybrids involving unnatural amino acids or inorganic materials. - Demonstrate a robust understanding of the collective mechanisms that contribute to cell death. - Identify and initiate strategies that would enable a new generation of regenerative cells that could ultimately be programmed to live indefinitely until needed for an injury repair or therapeutic application. - Develop genetically encoded locks to create "tamper proof" DNA and protect commercial applications. - Develop strategies to create a synthetic organism "self-destruct" option to be implemented upon nefarious removal of organism. - Permanently append a synthetic organism's genome and prevent foul play by tracking organism use and history, similar to a traceable serial number on a handgun.					
Pathogen Defeat	0.000	0.000	4.000	0.000	4.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) Pathogens are well known for the high rate of mutation that enables them to escape drug therapies and primary or secondary immune responses. The Pathogen Defeat thrust area will provide revolutionary capabilities to predict future threats and to deflect pathogen evolution to non-human spaces such as animals, insects, and bacteria. This area will also determine malicious intent by monitoring key technology acquisitions and commercialization of potential dual-use technologies. Pathogen Defeat focuses not on the threats that are already known but rather on the threats of newly emerging agents and mutations in the future, allowing pre-emptive preparation of vaccine and therapy countermeasures. *FY 2011 Base Plans:* - Determine methods to predict intent of biohackers. - Begin to examine virus mitigation and frequency across the globe to predict the timing and geographic location of reassortment events. - Identify low-resource requirement bioweapons and respective countermeasures. - Develop processes to accurately predict the drift and shift of viral reservoirs. - Create viral reservoir specific countermeasures that prevent emergence of novel highly lethal pathogens.					
Reliable Neural-Interface Technology (RE-NET) (U) The goal of the Reliable Neural-Interface Technology (RE-NET) program is to develop technology needed to reliably extract information from the nervous system, and to do so at a scale and rate necessary to control many degree-of-freedom (DOF) machines, such as high-performance prosthetic limbs. This program will complement ongoing DARPA neural prosthetic activities funded through other DARPA programs. These activities study cognition and the mechanisms of higher brain function, as well as upper-limb prostheses and motor-decoding algorithms. RE-NET will develop the technologies needed to allow the best robotic prosthetic-limb technology, recently developed by DARPA, to be reliably used throughout the life of wounded warriors that have one or more amputated limbs.	0.000	6.000	20.000	0.000	20.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Advance peripheral nervous system (PNS) interface technology to increase the channel count and hence neural information content, while not compromising the existing long-term reliability capability. - Perform fundamental tissue-response-assessment experiments using both existing and new central nervous system (CNS) interface technology. - Develop statistically validated models of electrode channel loss as well as methods to predict long-term interface failure. *FY 2011 Base Plans:* - Advance CNS interface technology to increase its functional lifetime, while not compromising their ability to obtain large amounts of neural information. - Demonstrate advanced Reliable CNS Interface (RCI) technology in models with systems that have at least 100 channels and do not lose more than 1% of the channels per year.					
Accomplishments/Planned Programs Subtotals	120.451	128.845	137.000	0.000	137.000

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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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602716E: *ELECTRONICS TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	181.519	179.402	286.936	0.000	286.936	348.377	327.984	347.871	347.534	Continuing	Continuing
ELT-01: *ELECTRONICS TECHNOLOGY*	181.519	179.402	286.936	0.000	286.936	348.377	327.984	347.871	347.534	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This program element is budgeted in the Applied Research budget activity because its objective is to develop electronics that make a wide range of military applications possible.

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

(U) The phenomenal progress in current electronics and computer chips will face the fundamental limits of silicon technology in the early 21st century, a barrier that must be overcome in order for progress to continue. Another thrust of the program element will explore alternatives to silicon-based electronics in the areas of new electronic devices, new architectures to use them, new software to program the systems, and new methods to fabricate the chips. Approaches include nanotechnology, nanoelectronics, molecular electronics, spin-based electronics, quantum-computing, new circuit architectures optimizing these new devices, and new computer and electronic systems architectures. Projects will investigate the feasibility, design, and development of powerful information technology devices and systems using approaches for electronic device designs that extend beyond traditional Complementary Metal Oxide Semiconductor (CMOS) scaling, including non silicon-based materials technologies to achieve low cost, reliable, fast and secure computing, communication, and storage systems. This investigation is aimed at developing new capabilities from promising directions in the design of information processing components using both inorganic and organic substrates, designs of components and systems leveraging quantum effects and chaos, and innovative approaches to computing designs incorporating these components for such applications as low cost seamless pervasive computing, ultra-fast computing, and sensing and actuation devices. This project has five major thrusts: Electronics, Photonics, MicroElectroMechanical Systems, Architectures, Algorithms, and other Electronic Technology research.

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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	199.396	223.841	0.000	0.000	0.000
Current President's Budget	181.519	179.402	286.936	0.000	286.936
Total Adjustments	-17.877	-44.439	286.936	0.000	286.936
• Congressional General Reductions		-0.752			
• Congressional Directed Reductions		-65.687			
• Congressional Rescissions	-2.092	0.000			
• Congressional Adds		2.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-10.183	0.000			
• SBIR/STTR Transfer	-5.602	0.000			
• Congressional Restoration for New Starts	0.000	20.000	0.000	0.000	0.000
• TotalOtherAdjustments	0.000	0.000	286.936	0.000	286.936

Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2009	FY 2010
Project: ELT-01: *ELECTRONICS TECHNOLOGY*		
Congressional Add: *3-D Technology for Advance Sensor Systems*	1.440	2.000
Congressional Add: *Secure Media and ID Card Development*	0.240	0.000
Congressional Add Subtotals for Project: ELT-01	1.680	2.000
Congressional Add Totals for all Projects	1.680	2.000

Change Summary Explanation

FY 2009

Decrease reflects transfer of the "Indium Base Nitride Technology Development" congressional add within RDT&E Defense-Wide, Section 8042 rescission of FY 2010 Appropriations Act, SBIR/STTR transfer and internal below threshold reprogramming.

FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts offset by congressional adds (as identified above) and FY 2010 Congressional Restoration for New Starts.

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FY 2011
Not Applicable

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Advanced Microsystems Technology Program	5.000	5.000	5.000	0.000	5.000
(U) The Advanced Microsystems Technology program explores a range of advanced microsystem concepts well beyond existing current technologies. The program focus is on technologies that exploit 3-Dimensional (3-D) structures, new materials for Gieger mode detectors, advance patterning, and extreme scaling in silicon devices. Insights derived in these areas will be exploited in future program initiatives. *FY 2009 Accomplishments:* - Prepared report analyzing prospects for beyond roadmap technologies. - Delivered data on ultra-low voltage operation of Silicon Complimentary Metal Oxide Semiconductor (CMOS) for DoD applications. *FY 2010 Plans:* - Demonstrate midwave IR (MWIR) photon-counting arrays using antimonide-based avalanche photodiodes. - Demonstrate nanolithography techniques which enable use of electron-beam lithography in conjunction with interferometric optical patterning or templated self-assembly. *FY 2011 Base Plans:* - Demonstrate focal planes using dense monolithic 3-D integration of silicon electronics and compound semiconductor detectors. - Demonstrate ultralow-power silicon CMOS technology optimized for DoD applications such as space electronics, long endurance microsensors, and extreme temperature electronics.					
High Frequency Wide Band Gap Semiconductor Electronics Technology	15.564	14.108	20.320	0.000	20.320

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The overall objective of the High Frequency Wide Band Gap Semiconductors Electronic Technology initiative is to fully exploit the properties of wide bandgap semiconductors (WBGS) to enhance the capabilities of microwave and millimeter-wave (MMW) monolithic integrated circuits (MMICs) and in turn, enable future RF sensor, communication, and multifunction military capabilities. The program will also develop revolutionary nitride transistor technology that simultaneously provides extremely high-speed and high-voltage swing [Johnson Figure of Merit larger (JFoM) than 5 THz-v] in a process consistent with large scale integration in enhancement/depletion (E/D) mode logic circuits of 1,000 or more transistors. In addition, this fabrication process will be manufacturable, high-yield, high-uniformity, and highly reliable. Wide bandgap semiconductors have the ability to deliver very high-power and other very favorable high frequency characteristics. Prior efforts have focused on improvements to the basic semiconductor while current efforts are focused on realizing devices and circuits. These technologies will lead to affordable, high performance, reliable, wide bandgap devices and MMICs with characteristics suitable for enabling new DoD systems and greatly improved performance for fielded platforms. *FY 2009 Accomplishments:* - Identified thermal management concepts to sustain more than 1 KW/cm squared power density in high-power devices. - Optimized wide bandgap semiconductor materials to achieve 100 mm substrates with less than 10 micropipe/cm squared and resistivity greater than 10^7 ohms-cm at room temperature. - Demonstrated fabrication processes for robust microwave and mm-wave devices with radio frequency yields greater than seventy percent. - Demonstrated thermal management concepts to sustain more than 1 KW/cm squared power density in high power device. - Developed processes that enabled highly scaled Enhancement-mode (E-mode) and Depletion-mode (D-mode) operation High Electron Mobility Transistor devices.					

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop and utilize physics-based models that accurately predict device performance. - Demonstrate reproducible WBGS device and MMICs fabrication processes. - Demonstrate WBGS devices and MMICs that, while maintaining high levels of producibility and reliability, achieve substantially higher levels of performance compared to GaAs-based microwave and MMW devices and MMICs. - Demonstrate superior thermal management and packaging strategies. - Develop self-aligned structure with short gate length, novel barrier layers and reduced parasitics. - Demonstrate technologies to achieve circuits of significant complexity (~1,000 transistor devices or more). - Develop transistor models. *FY 2011 Base Plans:* - Develop high-performance Gallium Nitride Field Effect Transistors (FET). - Optimize transistor performance. - Achieve yield to enable modest integration levels.					
Quantum Information Science (QIS) (U) The Quantum Information Science (QIS) program will explore all facets of the research necessary to create new technologies based on quantum information science. Research in this area has the ultimate goal of demonstrating the potentially significant advantages of quantum mechanical effects in communication and computing. Expected applications include: new improved forms of highly secure communication; faster algorithms for optimization in logistics and wargaming; highly precise measurements of time and position on the earth and in space; and new image and signal processing methods for target tracking. Technical challenges include: loss of information due to quantum decoherence; limited communication distance due to signal attenuation; limited selection of algorithms and protocols; and larger numbers of bits. Error correction codes, fault tolerant schemes,	7.985	6.200	5.450	0.000	5.450

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and longer decoherence times will address the loss of information. Signal attenuation will be overcome by exploiting quantum repeaters. New algorithm techniques and complexity analysis will increase the selection of algorithms, as will a focus on signal processing. The QIS program is a broad-based effort that will continue to explore the fundamental open questions, the discovery of novel algorithms, and the theoretical and experimental limitations of quantum processing as well as the construction of efficient implementations. *FY 2009 Accomplishments:* - Investigated unresolved fundamental issues related to quantum information science. - Employed qubit architectures to demonstrate applications of interest to the DoD (e.g., quantum repeater, secure metropolitan-area network). - Demonstrated interoperation between multiple qubit types to interconnect quantum communications links. *FY 2010 Plans:* - Measure single electron spin lifetime and demonstrate controlled gate operations in gated quantum dots (QD) in silicon (Si). - Conduct theoretical analysis of improvement in decoherence time resulting from dynamical decoupling schemes. - Explore novel materials, noise characteristics and decoherence mitigation strategies for superconducting qubits. *FY 2011 Base Plans:* - Measure single electron spin decoherence time in gated QD in Si. - Demonstrate entanglement swapping protocol in three QD devices in Si. - Perform state tomography and dispersive readout for one and two superconducting qubits. - Fabricate high quality superconducting tunnel junctions through material improvement.					
Feedback-Linearized Microwave Amplifiers	5.885	2.650	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) Modern military platforms require increased dynamic range receivers for their onboard communications in both radar and electronic warfare antenna systems. The goal of the Feedback-Linearized Microwave Amplifiers program is to develop radio frequency (RF) amplifiers with revolutionary increased dynamic range receivers through the use of linear negative feedback. This program will develop the core technologies and components that may be used as building blocks and/or modules in future system applications. *FY 2009 Accomplishments:* - Developed and enhanced Indium Phosphate (InP) Hetrojunction BiPolar Transistor (HBT)-based RF operational amplifier and InP High Electron Mobility Transistor (HEMT)-based ultra-low-noise amplifier. *FY 2010 Plans:* - Demonstrate feedback-linearized all-HBT monolithic low-noise amplifier with improved third-order-intercept point and noise factor. - Demonstrate feedback linearized InP HEMT monolithic low-noise amplifier. - Establish packaging technology for composite low-noise amplifier module.					
Terahertz Electronics (U) Terahertz Electronics will develop the critical semiconductor device and integration technologies necessary to realize compact, high-performance microelectronic devices and circuits that operate at center frequencies exceeding 1 Terahertz (THz). There are numerous benefits to operating in the THz regime and multiple new applications in imaging, radar, communications, and spectroscopy, all enabled by electronics that operate in the THz frequency regime. The Terahertz Electronics program is divided into two major technical activities: Terahertz Transistor Electronics that includes the development and demonstration of materials and processing technologies for transistors and integrated circuits for receivers and exciters that operate at THz frequencies; and Terahertz High Power Amplifier (HPA) Modules that includes the development and demonstration of device and processing technologies for high power amplification of THz signals in compact modules.	12.256	13.980	17.720	0.000	17.720

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed devices and circuits for candidate applications with demonstration of operation at a frequency of at least 0.67 THz. - Demonstrated 18dBm power amplification at 0.67 THz. *FY 2010 Plans:* - Develop devices and circuits for candidate applications with demonstration of operation at a frequency of at least 0.85 THz. - Demonstrate 14dBm power amplification at 0.85 THz. *FY 2011 Base Plans:* - Achieve key device and integration technologies to realize compact, high performance electronic circuits operating beyond 1 THz.					
Carbon Electronics for RF Applications (CERA) (U) The Carbon Electronics for RF Applications (CERA) program will develop a wafer-scale graphene (2-Dimensional carbon monolayer) synthesis process resulting in films with excellent mobility, uniformity and layer control (down to single monolayer films). These carbon films will then be used to develop ultra-low power, high-speed field effect transistors optimized for RF-applications (RF-FET). The program will conclude with a demonstration of a low power, low noise amplifier (LNA) using graphene-field effect transistors (FETs) as the channel material. *FY 2009 Accomplishments:* - Developed synthesis process for wafer-scale graphene thin films. - Demonstrated feasibility of graphene channel based FETs. *FY 2010 Plans:* - Optimize synthesis process for wafer-scale graphene thin films.	10.032	7.898	6.958	0.000	6.958

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Optimize RF-FETs based on graphene channels. *FY 2011 Base Plans:* - Increase area of graphene synthesis to wafer-scale dimensions. - Demonstrate film thickness control down to single monolayer. - Demonstrate low power, high performance RF-FETs with graphene. - Demonstrate initial wide-band LNA using graphene channel based RF-FETs.					
Compound Semiconductor Materials On Silicon (COSMOS) (U) The objective of the Compound Semiconductor Materials On Silicon (COSMOS) program is to develop a robust semiconductor fabrication technology and manufacturing process for the intimate integration of multiple types of devices and semiconductor materials. Conventional semiconductor processing is limited to one type of semiconductor but most DoD systems have circuits with multiple types of semiconductor circuits and devices. This program is developing heterogeneous material and device fabrication technologies to allow compound semiconductors to be directly integrated with standard silicon. The high yield fabrication approaches will allow the various materials to be in close proximity. This program is also focusing on innovations in design to ensure that the resulting composite circuits realize superior performance in advanced circuit demonstrations. *FY 2009 Accomplishments:* - Fabricated wafers using the COSMOS process. - Evaluated alignment and bonding methods to achieve mechanical integrity of dissimilar materials, post-processing compatibility with complimentary metal-oxide semiconductor (CMOS), and the achievement of high fabrication yields. - Extended the capabilities of wide bandgap devices for use in power amplifiers (PAs) at frequencies at least as high as X-band and to make this technology useful at very high frequencies. - Demonstrated large (greater than 1 mm) devices.	14.760	10.834	9.116	0.000	9.116

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Decreased the number of optical phonons in the critical gate region of radio frequency (RF) PA devices. *FY 2010 Plans:* - Increase the density of heterogeneous interconnections between compound semiconductors and silicon. - Implement process enhancements to improve the yield of the heterogeneous interconnect process. - Complete design of an advanced mixed-signal circuit demonstrator such as a heterogeneously-integrated 13-bit digital-to-analog converter. *FY 2011 Base Plans:* - Complete design of a complex mixed signal circuit demonstration vehicle, such as a heterogeneously-integrated 16-bit analog-to-digital converter. - Implement the COSMOS process to demonstrate that fine-scale heterogeneous integration can be realized on a large-scale circuit and that the performance benefits can be realized.					
Steep-subthreshold-slope Transistors for Electronics with Extremely-Low Power (STEEP) (U) The Steep-subthreshold-slope Transistors for Electronics with Extremely-low Power (STEEP) program goal was to develop revolutionary transistor technologies, which enabled devices to be operated at voltages as low as 0.2 V without loss in performance (defined by available drive current). The approach was to develop novel transistors with sub-threshold “turn-on” slopes as sharp as 20 millivolt (mV)/decade while maintaining excellent current drive characteristics. This program mainly focused on developing band-to-band tunneling transistors that will be operated at low bias voltages with high saturation current and low leakage current. In addition, associated device models were developed in the program to enable novel ultra-low power circuit designs. At the end of the program, complex demonstration circuits achieved significant power savings, both active and standby, of at least twenty-five times. The STEEP transistors utilized the mechanism of gate controlled modulation of the energy band alignment between the conduction and valence bands of a band-to-band-tunneling device. The	4.218	0.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
key technical challenges of the program included (1) achieving steep sub-threshold slope over many decades of current, (2) developing CMOS compatible fabrication flow, (3) developing novel circuit designs accommodating asymmetric source-drain doping, (4) demonstrating abrupt doping profiles at tunneling junctions, and (5) integrating silicon-germanium (SiGe), germanium (Ge), or group III-V material in the transistor structures to facilitate the required tunneling currents. The STEEP program started with the development of transistors with less than 30mV/dec of sub-threshold slope and then proceeded to demonstrate the integration of these devices into logic circuits using an eight inch wafer technology. Finally, the STEEP program focused on the yield improvement of a complex ultra-low power static random access memory (SRAM) circuit. *FY 2009 Accomplishments:* - Developed associated device models of band-to-band tunneling transistors. - Engineered transistor structures and began fabrication of key device modules capable of meeting performance milestones of low power consumption and good performance.					
Leading Edge Access Program (LEAP) (U) The Leading Edge Access Program (LEAP) is a companion effort to the STEEP program and its focus is to enable university, industry, and government lab access to on-shore state of the art Complementary Metal Oxide Semiconductor (CMOS) technology for the purpose of performing advanced integrated circuit (IC) research of benefit to the DoD. Specifically, LEAP intends to offer foundry access at a substantially reduced cost for CMOS technology nodes of 45 nanometers (nm) and below. Currently much of the IC design work performed using advanced technology nodes, including that done for the DoD, uses off-shore facilities in Asia and Europe. This results in substantial intellectual property (IP) development outside the U.S. and creates a number of difficulties for technology transition of DoD-critical applications. This program will stimulate U.S.-based advanced design research, providing top researchers early and partially subsidized access to validate and test innovative ideas and facilitate a more natural transition of pioneering ideas.	1.000	3.210	3.210	0.000	3.210

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Began research in 45 nm silicon on insulator (SOI). *FY 2010 Plans:* - Initiate transition of 45 nm SOI to 32 nm bulk CMOS. *FY 2011 Base Plans:* - Transition to 32 nm SOI, 22 nm bulk CMOS, and 22 nm SOI.					
High Frequency Integrated Vacuum Electronic (HiFIVE) (U) The objective of the High Frequency Integrated Vacuum Electronic (HiFIVE) program is to develop and demonstrate new high-performance and low-cost technologies for implementing high power millimeterwave sources and components. This program is developing new semiconductor and micro-fabrication technologies to produce vacuum electronic (VE) high-power amplifiers (HPAs) for use in high-bandwidth, high-power transmitters. Innovations in design and fabrication are being pursued to enable precision etching, deposition, and pattern transfer techniques to produce resonant cavities, electrodes, and magnetics, and electron emitting cathodes for compact high-performance millimeter wave devices. These new technologies will eliminate the limitations associated with the conventional methods for assembly of high-power sources in this frequency range. *FY 2009 Accomplishments:* - Validated cold test interaction of structure design and high current density cathodes. - Explored/identified novel material to optimize circuit performance characteristics. *FY 2010 Plans:* - Validate the design of a high power amplifier through experiments and computational simulation. - Complete development of the high-performance cathode prototype and demonstrate its ability to operate without degradation for at least 1000 hours.	11.876	8.430	11.120	0.000	11.120

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete advanced cathode development activities. - Complete fabrication and initial testing of a high power amplifier prototype device incorporating HiFIVE micro-fabrication technologies. - Initiate efforts to perform laboratory measurements of performance.					
Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF) (U) The Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF) program will increase the tuning speed of high-temperature semiconducting (HTS) filters, from about a second with present mechanical methods, to microsecond speeds required for systems such as the Joint Tactical Information Distribution System (JTIDS). The technology for such a million-fold improvement relies upon semiconductor tuning, properly mated with the superconducting filter materials; the fundamental challenge – that normal electrical conductivity and superconductivity cannot coexist in the same circuit – has been overcome. In addition to interference-rejection at microsecond speeds, these filters make it possible to perform wide spectral searches with unprecedented frequency resolution, enabling detection of very weak emissions (signatures) characteristic of threat systems. Such a capability within a small add-on box to the RF receiver, will revolutionize the performance of all types of receivers, with applications ranging from communications to signals intelligence, and enable operation in the densest of interference environments. *FY 2009 Accomplishments:* - Designed and demonstrated the capability for a usable tunable-superconducting filter bank system within the frequency range 400 - 3,000 MHz, with multiple sub-bands each tunable to about 20% of the mean range. The minimum bandwidth requirement is 5 MHz (consistent with a fractional bandwidth of 0.5% at 1 GHz). The prior accomplishments for filter switching time, insertion loss and out-of-band rejection were maintained.	5.287	1.298	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Evolve a concept for a front-end pre-selector filter bank, consisting of both tunable notch and bandpass filters, which would demonstrate the capability of removing local interference, particular those agile signals such as JTIDS. - Construct a pre-selector module, incorporating HTS filters and supporting circuitry, and demonstrate the capability of eliminating interference in the first stage of the receiver.					
Chip-to-Chip Optical Interconnects (C2OI)	3.112	1.025	0.000	0.000	0.000
(U) Continuing advances in integrated circuit technology are expected to push the clock rates of Complimentary Metal-Oxide Semiconductor (CMOS) chips into the 10 gigahertz (GHz) range over the next four to six years. At the same time, copper-based technologies for implementing large number of high-speed channels for routing these signals on a printed circuit board and back planes are expected to run into fundamental difficulties. This performance gap in the on-chip and between-chip interconnection technology will create data throughput bottlenecks affecting military-critical sensor signal processing systems. To address this pressing issue, this program is developing optical technology for implementing chip-to-chip interconnects at the board and back plane level. *FY 2009 Accomplishments:* - Developed a chip-scale opto-electronic transceiver circuit based on C2OI technology and demonstrated operation equivalent to 1 Terabit per second (Tbit/s) (consisting of twenty-four bidirectional channels each operating at 20 Gigabits/second (Gb/s)). - Developed a chip-scale opto-electronic transceiver consisting of twelve bidirectional channels each operating at 15 Gb/s that is fully integrated with commercially manufactured circuit boards. *FY 2010 Plans:* - Initiate efforts to complete a full system-scale demonstration of the use of C2OI technology approaches through the optical interconnect of two high performance computer servers using embedded C2OI technology with commercial circuit boards.					

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Complete a Technology/Manufacturing Readiness Assessment for C2OI technology with respect to commercial supercomputing and military high-performance embedded computing environments.					
Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) (U) The vision of the Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) program is the development of biological-scale neuromorphic electronic systems for autonomous, unmanned, robotic systems where humans are currently the only viable option. The successful development of this technology will revolutionize warfare by providing intelligent terrestrial, underwater, and airborne systems that remove humans from dangerous environments and remove the limitations associated with today's remote-controlled robotic systems. Applications for neuromorphic electronics include not only robotic systems, but also natural human-machine interfaces and diverse sensory and information integration applications in the defense and civilian sectors. If successful, the program will also reinvigorate the maturing microelectronics industry by enabling a plethora of computer and consumer electronics applications. *FY 2009 Accomplishments:* - Developed a nanometer scale electronic synapse exhibiting the critical communication, processing and learning functions of biological synapses. - Developed microcircuit architecture employing hybrid complementary metal oxide semiconductor (CMOS) and high-density electronic synapses to replicate core functions of lower-level biological neural systems. *FY 2010 Plans:* - Develop a brain-inspired neuromorphic architectural design and specification capability. - Develop software tools to translate neuromorphic designs into electronic implementations using hybrid CMOS and high-density electronic synapse components. - Develop capability to simulate the performance of neuromorphic electronics systems using very large scale computation.	19.530	18.849	19.608	0.000	19.608

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop virtual reality environments intended for training and evaluating electronic neuromorphic systems and their corresponding computer simulations. - Develop standard testing protocols for assessing the performance of large neuromorphic electronic systems. *FY 2011 Base Plans:* - Demonstrate all core microcircuit functions in hybrid CMOS/electronic synapse hardware. - Demonstrate a dynamic neural system simulation of approximately one million neurons that shows plasticity, self-organization, and network stability in response to sensory stimulus and system level reinforcement. - Develop the ability to design electronic neuromorphic systems of 100 billion neurons with mammalian connectivity. - Demonstrate virtual environments with a selectable range of complexity across the cognitive capabilities of small to medium sized mammals. - Specify a chip fabrication process supporting 1 million neurons per square centimeter and ten billion synapses per square centimeter.					
Ultrabeam (U) The goal of the Ultrabeam program is to demonstrate the world's first gamma-ray laser using laboratory equipment. Compact gamma ray lasers can enable the development of new and more effective radiation therapies and radiation diagnostic tools for medical and materials/device inspection applications. This unique X-ray laser technology could also eventually enable the development of compact, laboratory-scale high-brightness coherent sources for 3-Dimensional molecular scale imaging of living cells and debris-free advanced lithography. *FY 2009 Accomplishments:* - Demonstrated excitation of inner shell and nuclear levels in candidate gamma ray gain media.	3.419	1.647	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrated modeled gain of greater than 50 cm^-1 in high atomic-number (Z greater than 70) candidates. - Estimated X-ray source scaling limits and source requirements for candidate gamma ray gain systems. - Demonstrated 50 milli Joule (mJ), 0.03 femtosecond (fs) X-ray laser output pulse. *FY 2010 Plans:* - Demonstrate gamma-ray amplification with a gain of greater than 100 cm^-1.					
Radio Isotope Micro-Power Sources (RIMS) (U) The Radio Isotope Micro-Power Sources (RIMS) effort will develop the technologies and system concepts required to safely produce electrical power from radioisotope materials for portable and mobile applications, using materials that can provide passive power generation. There will also be research in compact radioisotope battery approaches that harness MicroElectroMechanical Systems (MEMS) technology to safely and efficiently convert radioisotope energy to either electrical or mechanical power while avoiding lifetime-limiting damage to the power converter caused by highly energetic particles (e.g., such as often seen in previous semiconductor approaches to energy conversion). The goal is to provide electrical power to macro-scale systems such as munitions, unattended sensors, and weapon systems, radio frequency identification tags, and other applications requiring relatively low (up to tens of milliwatts) average power. *FY 2009 Accomplishments:* - Demonstrated advanced dielectrics with high stability suitable for solid-state capture devices. *FY 2010 Plans:* - Optimize source and dielectric for integrated power system designs.	1.229	1.140	0.000	0.000	0.000
Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM)	3.000	2.500	0.000	0.000	0.000

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The goal of the Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM) program is to develop and demonstrate new technologies for Group II-VI (e.g., Cadmium Selenide (CdSe)) and III-V (e.g., Gallium Nitride (GaN)) materials and device manufacturing, enabling imaging and emissive device fabrication at one percent to ten percent of current costs. This advance will dramatically expand the application space of such devices, by providing lower cost per large area infrared (IR) imaging systems, non-planar devices and systems, and thin film and flexible devices and systems. This program will demonstrate IR detectors and imagers, Light Emitting Diodes (LED), and solid-state lasers fabricated via new methods, and include a rapid demonstration of at least five times reduction in yielded device cost. *FY 2009 Accomplishments:* - Developed and demonstrated techniques for layer doping of heterostructure materials. - Grew monocrystaline p-type GaN material with biased target based deposition based manufacturing process. - Demonstrated lift-off and substrate recycling. - Identified process optimization paths for improved material characteristics and expanded potential suite of low-cost devices that can be fabricated. *FY 2010 Plans:* - Demonstrate fabrication technologies that support the fabrication of affordable emissive microdisplays. - Extend novel fabrication techniques to demonstrate initial device concepts. - Demonstrate scalability of novel manufacturing techniques.					
Short-range Wide-field-of-regard Extremely-agile Electronically-steered Photonic Emitter and Receiver (SWEEPER) (U) The objective of the Short-range Wide-field-of-regard Extremely-agile Electronically-steered Photonic Emitter and Receiver (SWEEPER) program is to develop chip-scale dense waveguide	1.000	2.800	6.800	0.000	6.800

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
modular technology to achieve true embedded phase array control for beams equivalent to 10W average power, less than 0.1 degree instantaneous field of view (IFOV), greater than 45 degree total field of view (TFOV), and frame rates of greater than 100 Hertz (Hz) in packages that are "chip-scale." Such performance will represent a three order of magnitude increase in speed, while also achieving a greater than two orders of magnitude reduction in size. Additionally, the integrated phase control will provide the unprecedented ability to rapidly change the number of simultaneous beams, beam profile, and power-per-beam, thus opening a whole new direction in operational capability. Key technical challenges include the ability to achieve the needed facet density (facet pitch should be on the order of a wavelength or two), control the relative phase across all facets equivalent to 9-bits, and efficiently couple and distribute coherent light to facets from a master laser oscillator with an integrated waveguide structure. Related projects and studies have pointed to the significant system-level pay-offs of the new proposed technology. *FY 2009 Accomplishments:* - Began research on transmit and receive photonic phased array technologies. *FY 2010 Plans:* - Evaluate transmit and receive photonic phased array technologies. *FY 2011 Base Plans:* - Demonstrate chip scale beam-forming capability in laboratory. - Demonstrate integrated photonic phased array transceiver concept.					
Analog-to-Information (A-to-I) (U) The Analog-to-Information (A-to-I) program will leverage recent dramatic breakthroughs in digitization techniques and hardware to enable accurate extraction of useful information from broadband environments crowded with diverse signals and interference spread over a large dynamic range. The program will satisfy DoD's requirements for radio frequency (RF) applications of the present	5.970	9.910	7.120	0.000	7.120

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and the future. Additionally, by extracting signals of interest during the measurement phase, A-to-I based approaches reduce the bandwidth and resolution requirements of analog-to-digital converters, and simultaneously reduce the data glut that impacts downstream processing of digitized signals. *FY 2009 Accomplishments:* - Systematically exploited practical hardware and software implementations of the most promising approaches from study phase: compressive sampling, variable projective unfolding, and nonlinear affine encoders. *FY 2010 Plans:* - Prototype critical hardware components of the design in order to avoid risk early; models based on performance measurements of these components will be incorporated into the simulation of the overall receiver. *FY 2011 Base Plans:* - Develop and demonstrate brassboard A-to-I receivers and demonstrate against realistic and challenging RF environments in simulator, chamber, and/or live field tests.					
MultiScale Optical Sensor Array Imaging (MOSAIC)* *Formerly Computational Imaging (CI). (U) The Multiscale Optical Sensor Array Imaging (MOSAIC) program will develop new imaging constructs that exploit the full information content (intensity, phase, and frequency) at the detection plan to perform real-time image processing in the analog domain. This will be combined with advanced digital image processing algorithms to leverage the unique image plane information for more rapid image analysis and target identification. This will lead to revolutionary advances in the detection, precision identification, tracking and destruction of elusive targets.	1.000	6.000	11.340	0.000	11.340

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Began the prototype development of a practical 3-Dimensional (3-D) spatial imager that captures intensity, frequency, and phase information of naturally illuminated scenery. *FY 2010 Plans:* - Demonstrate prototype 3-D spatial imager with associated spatial processing algorithms. *FY 2011 Base Plans:* - Demonstrate real-time tracking and automated-target recognition with improved robustness compared to conventional passive imaging systems.					
Electric Field Detector (E-FED) (U) The goal of the Electric Field Detector (E-FED) program is to develop a small room temperature electric field sensor/sensor array based on new optical electric field sensor architectures. Electric fields are ubiquitous in the warfighter environment. It is expected that these compact sensor arrays will be useful for the monitoring of brain activity and muscle action without the need to apply electrodes directly in or on the surface of the skin. The arrays would also be useful for the remote sensing of electronics, motors, and communications devices enabling the sensing of these devices at greater distances with a more unobtrusive and portable system. *FY 2009 Accomplishments:* - Explored techniques to control the effect of noise sources on the sensor function. *FY 2010 Plans:* - Demonstrate sensors sensitive to an alternating electric field of 1 million volts (mV)/mHz^1/2 from 1-10,000 Hertz (Hz). The sensor would have a dynamic range of 100 and a footprint size of no greater than 25 mm^2.	1.000	3.807	8.795	0.000	8.795

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Develop techniques to increase the frequency range, dynamic range and sensitivity of the electric field sensors while reducing their size. - Explore manufacturing techniques in order to produce electric field sensor arrays with high reproducibility.					
Integrated Photonic Delays (iPhoD) (U) The Integrated Photonic Delays (iPhoD) program will enable unprecedented integrated optical delay performance and complexity, thereby furthering the technological precision of our military. The iPhoD program will build the framework of a scalable integrated photonic platform technology that provides for the handling and manipulation of photons with throughput efficiency and precision approaching that of electrons within electronic integrated circuits. *FY 2009 Accomplishments:* - Demonstrated a minimum, on-chip, optical time delay of 100 nanoseconds (ns). *FY 2010 Plans:* - Refine waveguide materials, fabrication and coupling approaches. - Demonstrate a precise and low loss fiber input/output coupling technology. *FY 2011 Base Plans:* - Scale up and improve waveguide materials, processes, and devices to the performance levels needed for successful demonstration of an array processor. - Fabricate an array processor with at least 500 ns of on-chip optical delay for the longest path.	2.452	5.809	10.539	0.000	10.539
Quantum Sensors (U) The Quantum Sensors program exploits non-classical effects to improve the resolution and range of military sensors. The objective of the program is to enhance sensitivity, resolution, and effectiveness	3.612	5.089	9.639	0.000	9.639

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
of electromagnetic sensors beyond what is classically possible. In the initial effort, the types of sensors that propagate entangled light out to and back from a target were proven to be ineffective when realistic scattering and absorption occur between the source and the target. Sensors that propagate classical light to the target but use non-classical effects only in the receiver were shown to provide qualitative advantages over their classical counterparts. These include compensation for soft aperture losses using squeezed vacuum injection and compensation for detectors' quantum inefficiency using noiseless amplification. A new approach, quantum illumination, retains some entangled light in the receiver and transmits the remainder to the target promising substantial enhancements over detection and imaging of targets in the presence of high levels of noise and loss. *FY 2009 Accomplishments:* - Began engineering of a Type II sensor that: -- Demonstrated and quantified compensation of soft aperture loss by squeezed vacuum injection in homodyne laser radar in a range environment. -- Demonstrated noiseless amplification for sensors with low quantum efficiency. *FY 2010 Plans:* - Complete design and build laser radar with combined squeeze vacuum injection and noiseless amplification. *FY 2011 Base Plans:* - Complete system integration and field testing. - Transition technology to military services.					
Parametric Optical Processes and Systems (POPS) (U) The Parametric Optical Processes and Systems (POPS) program will demonstrate all optical signal processing based on Four Wave Mixing (FWM) in optical fibers and using silicon waveguides to achieve data rates of 100 Gigabits per second (Gb/s) to 1 Terabit per second (Tb/s). This program will develop	1.834	3.577	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
components such as wavelength-shifting wideband amplifiers, tunable optical delays, and parametric sampling for this application. These components will be used in higher level sub-systems such as serializers, de-serializers, and wavelength grooming devices at high data rates of 100 Gb/s - 1Tb/s. These demonstrations of functionality will also include quantitative bit error rate measurements. POPS components and subsystems will enable optical communications at data rates ten times higher than currently possible with conventional approaches. POPS technology will allow all optical manipulation of high rate data streams with a precision and flexibility not currently possible. *FY 2009 Accomplishments:* - Demonstrated serializer component with data rate of 320 Gb/s. - Demonstrated deserializer component with granularity of 40 Gb/s. - Demonstrated 500 ns continuous parametric delay technology. *FY 2010 Plans:* - Demonstrate enhanced serializer component with data rate of 640 Gb/s. - Demonstrate enhanced deserializer component with granularity of 10 Gb/s. - Demonstrate 3000 ns continuous parametric delay technology.					
Spin Torque Transfer-Random Access Memory (STT-RAM) (U) The Spin Torque Transfer-Random Access Memory (STT-RAM) program will develop materials and processes to fully exploit the spin-torque transfer (STT) phenomenon for creating “universal” memory elements. This program will develop the core technology for exploiting spin-torque transfer and related phenomena for producing large-scale memories. Compatibility and stability with expected mainstream processes for semiconductor electronics and patterned media is an important attribute that should enable significant leverage for these new technologies in delivering early demonstrations and in gaining wider acceptance.	2.978	5.277	7.565	0.000	7.565

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed fabrication techniques and device architectures that exploit various materials. *FY 2010 Plans:* - Develop magnetic materials and architectures that allow for fast low power switching in a STT architecture. - Demonstrate fast low power STT memory cell that has size and endurance similar to current non-volatile electronic memories. *FY 2011 Base Plans:* - Develop improved magnetic materials that allow for faster and lower power switching in the STT architecture. - Develop processes and circuit designs to manufacture operational memory arrays in high yield.					
Self-HEALing mixed-signal Integrated Circuits (HEALICs) (U) The goal of the Self-HEALing mixed-signal Integrated Circuits (HEALICs) program is to develop technologies to autonomously maximize the number of fully operational mixed-signal systems-on-a-chip (SoC) per wafer that meet all performance goals in the presence of extreme process technology variations, environmental conditions, and aging. This program is an outgrowth of mixed signal development in the Design Tools for 3-Dimensional Integrated Circuit program. Virtually all DoD systems employ mixed-signal circuits for functions such as communications, radar, navigation, sensing, high-speed image and video processing. A self-healing integrated circuit is defined as a design that is able to sense undesired circuit/system behaviors and correct them automatically. The motivation for this program came from findings under the TRUST program that, as semiconductor process technologies are being scaled to even smaller transistor dimensions, there is an exponential increase in intra-wafer and inter-die process variations, which have a direct impact on realized circuit performance manifested as significantly reduced yields of fabricated fully operational SoC. The core goal of the HEALICs program is to regain this lost performance. Additionally, the technology developed under this	11.500	15.310	16.810	0.000	16.810

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
program is expected to address environmental variations and aging as well. Consequently, the long-term reliability of DoD electronic systems is expected to be significantly enhanced. *FY 2009 Accomplishments:* - Developed self-healing control for individual sub-blocks within a larger mixed-signal core. - Integrated sub-blocks into larger mixed-signal cores (anticipated transistor counts in the 1k-10k range). - Developed global self-healing control algorithms. *FY 2010 Plans:* - Continue development of self-healing mixed-signal cores. - Demonstrate increase in performance yield of mixed-signal cores to greater than seventy-five percent with minimal power and die area overhead. *FY 2011 Base Plans:* - Integration of previously demonstrated mixed-signal cores into a full microsystems/SoC. - Develop global self-healing control at the microsystem/SoC level.					
COmpact Power Processing Electronics Research (COPPER) (U) The COmpact Power Processing Electronics Research (COPPER) program will address the fundamental limitations of power conversion by enabling a new technology and approach that exploits advances in basic power devices that can operate at very high frequencies with low losses. A key benefit of these new devices is that they can be integrated into very compact circuits and assemblies that will provide dramatic advances to the power bus of a platform. Specifically, this program will develop the technology to enable DC to DC power conversion for military applications at the scale of an integrated circuit so it can be embedded within the electronics subsystem and a new distributed power architecture can be realized. The focus of this program is on attaining 100MHz internal operation	0.000	0.000	7.000	0.000	7.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
frequencies of power circuits since the size of the passive elements (inductors and capacitors) in a power converter scales as the fourth power of the internal operating frequency. *FY 2011 Base Plans:* - Develop design and initial fabrication of critical sub-circuits and perform measurements in laboratory. - Develop theoretical design and analyses for understanding of the high-frequency trade-off space of relevant circuit designs and topologies. - Develop design of high frequency converter prototype. - Develop new fabrication techniques for incorporating high frequency transistors and devices with capacitors and inductors to realize the advanced converter. - Document measurements of converter efficiency and losses.					
Efficient Linearized All-Silicon Transmitter ICs (ELASTx)* *Formerly Millimeter-wave All-Silicon Transmitters (MASTR). (U) The goal of the Efficient Linearized All-Silicon Transmitter ICs (ELASTx) program is the development of revolutionary high-power/high-efficiency/high-linearity single-chip millimeter (mm)-wave transmitter integrated circuits (ICs) in leading edge silicon technologies. The high levels of integration possible in silicon technologies enable on-chip linearization, complex waveform synthesis, and digital calibration and correction. Military applications include ultra-miniaturized transceivers for satellite communications-on-the-move, collision avoidance radars for micro-/nano-air vehicles, and ultra-miniature seekers for self-guided munitions. The technology developed under this program could also be leveraged to improve the performance of high-power amplifiers based-on other non-silicon technologies through heterogeneous integration strategies. Significant technical obstacles to be overcome include the development of efficient circuits for increasing achievable output power of silicon devices (e.g., effective breakdown voltage enhancement, power combining) at mm-waves; scaling	0.000	5.804	11.583	0.000	11.583

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
high-efficiency amplifier classes to the mm-wave regime; robust mixed-signal isolation strategies; and thermal management considerations. *FY 2010 Plans:* - Demonstrate high-power (Watt-level), high power-added-efficiency (greater than or equal to fifty percent) power amplifier (PA) circuits at Q-band frequencies. - Develop design techniques for on-chip linearization of high-efficiency silicon PAs. *FY 2011 Base Plans:* - Demonstrate high-power (Watt-range) high power-added-efficiency (greater than or equal to fifty percent) PA circuits at W-band frequencies. - Demonstrate a Q-Band linearized transmitter with Watt-level output power, fifty percent range power added efficiency, and extremely high linearity for complex communications signals.					
Remoted Analog-to-Digital Converter with De-serialization and Reconstruction (RADER) (U) The objective of the Remoted Analog-to-Digital Converter with De-serialization and Reconstruction (RADER) program is to develop a novel analog to digital converter (ADC) front-end that acts as a performance multiplier for conventional ADCs. This program is an outgrowth of the Analog-to-Information research. The military's need to operate in dense signal environments, performing friendly communications and detecting low-power adversarial signals concurrently, requires ADCs with unparalleled resolution and wide instantaneous bandwidth (IBW). Commercial systems available today are capable of achieving high resolution, or wide bandwidth, but not both at the same time. To meet the military's need, the RADER program will develop a system that uses many commercial-off-the-shelf (COTS) ADCs in conjunction with a novel de-serializer front-end architecture to meet both the resolution and bandwidth requirements simultaneously. ADC systems enabled by RADER technology will be capable of operating in continuous time over a 10 GHz input IBW with a signal-to-noise resolution of 10 effective number of bits, an 8 bit improvement over COTS ADCs. These improvements will be accomplished using a remotable architecture in which most of the ADC's size, weight and power will	1.785	4.500	10.400	0.000	10.400

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
be remotely located from the signal environment—where space and supply power are more readily available (such as below a ship's deck) and the system itself will not alter the platform's center of gravity or create deleterious electronic noise for other systems *FY 2009 Accomplishments:* - Initiated system development of bandwidth measurements. *FY 2010 Plans:* - Develop Phase I RADER architecture. *FY 2011 Base Plans:* - Demonstrate 8 effective number of bits (ENOB) system operating at 10 GHz IBW. - Demonstrate 57 dB spurious free dynamic range (SFDR).					
Advanced CAD (U) The Advanced Computer-Aided Design (CAD) Program will radically overhaul the way circuit and system design is carried out, and in the process make the most advanced technologies under development for DoD use accessible to a far broader base of talented designers than at present. The principle aim of this effort is to develop a unifying framework for design and simulation of electronic systems that intelligently and seamlessly harmonizes the multiple interacting phenomena that must be dealt with in state-of-the-art system development. For example, it has become essential to consider, across length-scales from nanometers to meters, the actions and interactions of electronic, electromagnetic, mechanical, thermal, quantum, and fabrication process effects. Also, it is critical to co-optimize and co-design system functions across all of these domains – currently not possible. In the past, clunky individual software modules would separately estimate system behavior in one domain at a time, then pass the estimates to subsequent domain-specific codes. This program will result in a unified and modern code base for this purpose, importantly incorporating device and technology models reaching well beyond the state-of-the-art into cutting edge technologies. The program will	0.000	0.000	8.689	0.000	8.689

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
enable designers to explore all possible options. Another key goal of this effort is to integrate cognitive functions for immediate design assistance and real-time estimation to provide intuition-building feedback to the designer mimicking the effect of turning a knob and seeing what happens to a circuit on a bench. The overall outcome of this effort is expected to be a dramatic lowering of the barrier to entry for designers to access the best technologies, as well as a huge force multiplier in terms of designer productivity. *FY 2011 Base Plans:* - Demonstrate through simulations that co-design of processor algorithm achieves greater processing efficiency. - Develop tool set for design methodology for optimized co-design, demonstrating logical abstractions for hardware functional blocks and complex non-linear interactions between different functional blocks of a microsystem. - Investigate designs to demonstrate feasibility of two-times reduction in communication power for high density wafer-scale communication.					
Advanced Imaging (U) The ability to see farther with higher clarity and through darkness and/or obscurants is vital to nearly all military operations. At the same time, there is immense pressure to reduce the size, weight, and power (SWAP) requirements of advanced imaging systems. In the past, the main driver for this was the need for dismounted soldiers to carry the best available imaging tools – often a matter of life and death. With the advent of smaller and smaller UAVs, which can provide a huge advantage to our troops, the pressure to miniaturize and reduce power is even more intense. This program responds to that need by simultaneously pushing the envelope of imager performance through new detector devices and also dramatically reducing SWAP for UAV and head-worn applications. Technology approaches will include removing the power- and space-hungry cooling requirement of previous generation imagers,	0.000	0.000	7.844	0.000	7.844

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
pushing to increase resolution and sensitivity through new photon detectors such as nanoantenna-coupled detectors. *FY 2011 Base Plans:* - Investigate novel material and device designs that enable uncooled operation at infrared wavelengths. - Design of impedance-matched nano-structured antennas to couple long wavelength radiation to detector pixels in focal plan arrays with thousands of elements.					
Compact Mid-Ultraviolet Technology (U) The goal of the Compact Mid-Ultraviolet Technology program is to develop compact high-brightness Middle Ultraviolet source and detector technologies based on wide band gap diode structures. This program will address a critical technology shortfall preventing mid-UV capability in portable chem-bio defense systems for aerosol detection (enhanced capability for small particulates), chem-bio identification (Raman scattering and spectroscopy), and chemical decontamination/water purification applications. The technologies will also address solar-blind detectors for missile plume identification. *FY 2010 Plans:* - Develop large non-absorbing (UV transparent) low-defect-density substrate materials on which to grow devices. - Develop high-quality, highly-strained epitaxy to confine carriers and provide the required energy band offsets. - Initiate highly efficient electric injection of carriers to improve quantum efficiency. - Demonstrate low-resistance non-absorbing contacts. *FY 2011 Base Plans:* - Demonstrate diode operation at proposed mid-UV wavelength.	0.000	8.000	15.000	0.000	15.000

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C. Accomplishments/Planned Program ($ in Millions)

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- Create high-quality aluminum nitride (AlN) substrates to enable development of optimized devices. - Design and develop epitaxial structures for mid-UV light-emitting diode (LED) sources and detectors.					
Enabling Future Energy Concepts Through Microsystem Technologies (U) The DoD mission demands continuous pursuit of the most advanced portable, reliable and dense energy systems. A large number of critical systems are limited in performance and/or mission duration by the amount of electrical energy available at the point-of-use. This program seeks to create breakthrough advances in power storage, management and delivery, all enabled via the application of microsystems technologies. A core component of this effort will be the development of new architectures, reversible electrode structures, materials, and chemistries for the development of rechargeable, high energy density batteries that match or exceed energy density of hydrocarbon fuels (e.g. gasoline, JP8, etc.), requiring the energy density to increase over ten-fold compared to current lithium ion batteries. An equally important aspect of this program is the development of novel electromagnetic switching power converters to optimize the efficiency of energy use at the micro scale. In order to achieve this, both materials and circuits are necessary. Advanced micromagnetic materials and fabrication techniques will be developed to achieve greatly improved performance (i.e., > 100x higher magnetic permeability, > 20x higher magnetic-energy product, 140% higher magnetic saturation) in a reliable microsystem-compatible manner. With the resulting tiny inductors that can be directly merged with integrated circuits, it will be possible not only to allow every battery to optimize its own performance, but to allow integrated circuits to locally regulate their own energy supplies. This profound change away from centralized power systems will yield dramatic size, weight and efficiency improvements across scales from individual integrated circuits through entire phased-array radar and other large electronic systems. All of this translates into lower energy requirements, smaller logistics tails, reduced heat dissipation, and increased system reliability. *FY 2011 Base Plans:* - Investigate chemistry and materials to enable rechargeable high energy density batteries.	0.000	0.000	8.845	0.000	8.845

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate integration path for light sources and spherical atomic shells in arrays on a single wafer.					
Transformational Antenna Technologies (U) The Transformational Antenna Technology program goal is to develop and demonstrate new and innovative antenna design concepts that have the potential to fundamentally change the way that the Department of Defense (DoD) exploits the electromagnetic spectrum. The focus of the effort is to develop antennas that are physically or electrically small to support a variety of warfighter needs, such as applications including integration on small and micro UAVs, low observable platforms, soldier radios and manpacks. This program is attempting to reduce antenna size, provide additional sensitivity, and increase the frequency band over which small antennas operate. These techniques will give new levels of flexibility to our radio technology, enabling not only communications but intelligence gathering, jamming, and information operations on the same radio equipment, and implementation of new capabilities on smaller platforms such as UAVs. The antennas that will be developed will be smaller, and cover a wider range of frequency bands. The technologies and systems developed under this program support all Services. *FY 2011 Base Plans:* - Develop and model realistic electrically small antenna designs at a wide range of frequencies. - Develop methods of implementing transmit non-Foster matching circuits over wide bandwidths. - Develop integrated circuit designs that can be used to create specialized circuits for a wide range of impedance matching problems. - Develop methods to perform antenna beam management using only a single antenna port on a radio. - Develop methods to adjust antenna topology, resonant structure, and polarity. - Develop new scalable design techniques that support conformal implementation on surfaces of wings and fuselage of a variety of aircraft designs.	0.000	0.000	8.000	0.000	8.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Apply tunable superconducting filter development to specific radio receiver requirements for the Services.					
Terahertz (THz) Photonics (U) The Terahertz (THz) Photonics program will enable semiconductor continuous-wave laser sources that are THz frequency sources operating at room-temperature. Approaches to such sources include quantum cascade lasers and quantum dot lasers. Although the field of THz photonics has grown considerably, the physical path to an efficient continuous wave laser source at room temperature has eluded researchers prior to this program. The program will demonstrate designs that enable laser sources at these frequencies by mitigating the degradation of population inversion at room temperature. The program will invent an alternative laser active-region design, or more radically, use a new material system such as the gallium arsenide-based system to maintain the population inversion for lasing at room temperature. Highly efficient laser sources for portable systems such as infra-red counter-measures and active imagers will be enabled by this program. *FY 2011 Base Plans:* - Investigate laser designs for room temperature emission at THz frequencies.	0.000	0.000	6.745	0.000	6.745
Near-Junction Transports (NJT) (U) The Near-Junction Transport program will consist of fundamental research into heat conduction through materials layers near a high-power device junction. This program will develop and verify accurate quantitative models for heat generation and transport in and near device junctions to include development of novel high spatial and temporal resolution metrology techniques, fabrication of device-compatible materials and interfaces expected to offer unique thermal characteristics resulting in the development of models, tools, and materials for near-junction thermal management in a broad class of electronic device materials. The second stage will concentrate on development of specific materials to enhance the local heat-spreading in the region of the semiconductor chip. Industry leaders with the expertise in developing high-power semiconductor devices will be expected to demonstrate	0.750	2.750	10.150	0.000	10.150

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
significantly enhanced heat density and the use of enhanced heat spreading technologies within an existing fabrication process. Additionally, the program will address developing novel device-scale structures to enable highly conductive thermal paths to remove unwanted heat from electronic devices. The impressive improvements obtained through miniaturization and integration in electronics have led to a thermal bottleneck where dense logic circuits, mixed-signal analog and digital circuits, and RF electronics are all limited by energy dissipation in small volumes. Realizing the material benefits of gallium nitride and other wide band gap materials for power applications will not be possible unless the thermal conductance at or near an electronic junction is significantly improved. Power densities that approach material-limited performance for high powers may be enabled by integrating high conductivity materials, such as diamond films or nanostructures such as carbon nanotubes or graphene-related structures that control the phonon behavior to increase thermal conductance. This program is a companion program to the consolidated Thermal Management Technologies program in PE 0603739E, Project MT-12. *FY 2009 Accomplishments:* - Developed and verified accurate quantitative models for heat generation and transport in near device junctions. - Developed novel, high, spatial and temporal resolution metrology techniques. *FY 2010 Plans:* - Fabricate device-compatible materials and interfaces expected to offer unique thermal characteristics. - Develop models, tools, and materials for near-junction thermal management in a broad class of electronic device materials. *FY 2011 Base Plans:* - Develop specific materials to enhance the local heat-spreading in the region. - Develop high-power semiconductor devices.					

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate the use of enhanced heat spreading technologies within an existing fabrication process. - Demonstrate significantly enhanced heat density utilizing high-power semiconductor devices. - Identify nanostructured material designs for revolutionary thermal pathways compatible with electronic devices. - Explore the potential improvement possible by the use of phonon engineering.					
Non-Silicon Electronics The goal of the Non-Silicon Electronics program is to develop a new generation of vacuum electronic devices in which nano-scale structures are integrated with transistors to overcome traditional limitations in reliability and performance. While the commercial electronics world is almost totally dominated by silicon transistors, military systems can benefit enormously from the additional performance enabled by the use of alternate materials. These include phosphides (e.g., InP), antimonides (InSb), and nitrides (GaN). For example, the ability of GaN to achieve very high frequency operation while maintaining low on-state resistance offers an opportunity to achieve compact, even device-scale DC to DC power conversion systems. Such power conversion systems are virtually omnipresent, and by scaling their size by 10X or more while maintaining high efficiency would potentially lead to new capabilities such as chip-scale power converters. *FY 2011 Base Plans:* - Investigate designs for integrating vacuum electronic nano-structures with semiconductor-based transistors on the same wafer in order to demonstrate high efficiency, high power frequency sources. - Demonstrate RF and power electronics circuits using non-silicon transistor electronics.	0.000	0.000	7.725	0.000	7.725
Revolutionary Mixed-Signal Electronics (U) Since the earliest days of electronic circuits, there has been a synergistic relationship between the electronic device technology of the day and the circuit design ideas that combined them into systems of steadily increasing complexity and capability. While commercial industry is strongly	0.000	0.000	7.845	0.000	7.845

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
driving the scaling and performance increase of CMOS circuitry, an undesirable side-effect of the “Moore’s Law” scaling is the collapsing of the dynamic range (signal swing range) of analog circuits which are increasingly forced to coexist with digital circuits (on so-called “mixed-signal” integrated circuits). DoD requirements for electronics pull in exactly the opposite direction, requiring increased dynamic range, increased power density, and increased linearity, among other features. In order to harness commercial technologies and augment them to meet DoD needs, a combined approach will be taken, coupling evolving semiconductor device capabilities with innovative new circuit topologies. For example, new Gallium Nitride and vacuum devices will be harnessed to push to the limits of speed (terahertz), dynamic range, and power densities for applications such as extending the reach of radars and jam-proofing communications systems. Design techniques for optimally combining heterogeneous device technologies such as these with mainstream silicon circuits will allow the development of circuits with heretofore impossible performance capabilities. Finally, novel silicon-only design approaches will harness, at the lowest possible cost, secure commercial CMOS capabilities to trade abundant transistor speed for extended dynamic range, linearity and power efficiencies. Overall, this program seeks to develop entirely new designs and design methodologies to push the envelope of mixed signal performance across the entire spectrum of advanced device types available for DoD applications. *FY 2011 Base Plans:* - Design radio architectures that achieve 400 times reduction in signal recognition energy as compared to state of the art radios.					
Micro Isotope Micro-Power Sources (MIPS) (U) The goal of the Micro Isotope Micro-Power Sources (MIPS) program was to demonstrate safe, affordable micro isotope power sources able to outperform conventional batteries in terms of energy and/or power density, and provide long lasting milliwatt-level power for an array of critical military applications, such as unattended sensors, perimeter defense, detection of weapons of mass destruction, and environmental protection.	2.173	0.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Demonstrated radiation hardened Boron Carbon (BC) junctions with >10% efficiency. - Demonstrated thermophotovoltiac conversion system. - Demonstrated thermo electric conversion system.					
Visible InGan Injection Lasers (VIGIL) (U) The objective of the Visible InGan Injection Lasers (VIGIL) program was to demonstrate injection lasers emitting in the green wavelength. The specific program goal was to demonstrate continuous wave green injection lasers operating at room temperature with a power output up to 1 watt, wall plug efficiency of thirty percent, and laser output stability over time periods of at least 1000 hours. VIGIL lasers will enable applications requiring a close match between the wavelength of the light source and the peak response wavelength of the human eye. Another class of applications will take advantage of the minimum absorption of seawater in the blue-green spectral region. Other applications include miniaturized displays and pumps for generation of high-frequency mode-locked combs. *FY 2009 Accomplishments:* - Grew Indium Gallium NItride (InGaN) quantum wells with low defect densities (less than 10,000 defects per square cm) on both polar and non-polar Gallium Nitride substrates.	5.832	0.000	0.000	0.000	0.000
Chip Scale Atomic Clock (CSAC) (U) The Chip Scale Atomic Clock (CSAC) demonstrated a low-power chip scale atomic-resonance-based time-reference unit with stability better than one part per billion in one second. Application examples of this program will include the time reference unit used for Global Positioning System (GPS) signal locking.	1.371	0.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Demonstrated design and fabrication innovation for atomic-confinement cell and for gigahertz (GHz) resonators suitable for phase locking or direct coupling with atomic confinement cell.					
Photonic Analog Signal Processing Engines with Reconfigurability (PhASER) (U) The goal of the Photonic Analog Signal Processing Engines with Reconfigurability (PhASER) program was the creation of new Photonic Integrated Circuit (PIC) elements, and associated programmable filter array concepts that enabled high-throughput, low-power signal processors. The focus was on the development of novel "Unit Cells," which may be used as building blocks to synthesize arbitrarily complex filters within a PIC platform for ultra-high bandwidth signal processing applications. *FY 2009 Accomplishments:* - Demonstrated an experimental Unit Cell concept. - Determined how the Unit Cell, when arrayed within a high-density PIC performed. - Developed a filter synthesis tool to demonstrate how Unit Cells enabled generalized high-order filters. - Determined how unit cells were programmed and tested at the chip-level to ensure high yield.	3.995	0.000	0.000	0.000	0.000
Linear Photonic RF Front End Technology (PHOR-FRONT) (U) The goal of the Linear Photonic RF Front End Technology (PHOR-FRONT) program was to develop photonic transmitter modules that can adapt their frequency response and dynamic range characteristics to mate with the full spectrum of narrow-band and broadband microwave transmission applications covering the 2 Megahertz (MHz) – 20 Gigahertz (GHz) range. These field programmable, real-time adaptive photonic interface modules will find application in high dynamic range communications, radar and Electronic Warfare antenna applications.	2.875	0.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed compact linear photonic receivers with improved sensitivity and dynamic range.					
Optical Arbitrary Waveform Generation (OAWG) (U) The ultimate vision for the Optical Arbitrary Waveform Generator (OAWG) program was to demonstrate a compact, robust, practical, stable octave-spanning optical oscillator, integrated with an encoder/decoder capable of addressing individual frequency components with an update rate equal to the mode-locked repetition rate. This would provide an unprecedented level of performance for optical systems, and enable numerous high-level applications including sub-diffraction-limited imaging and ultra-wide band optical communications. *FY 2009 Accomplishments:* - Demonstrated production of pseudo-random pulse sequence with 5 GHz instantaneous bandwidth and measurement of 24 dB gain in matched filter output. - Investigated insertion of OAWG technology into high performance radar and laser radar systems. - Constructed system to produce 1,000 GHz positive linear chirp with less than five percent least-squared deviation from mathematical ideal waveform and built single-pulse waveform measurement instrumentation.	4.284	0.000	0.000	0.000	0.000
Adaptive Focal Plane Arrays (AFPA) (U) The goal of the Adaptive Focal Plane Arrays (AFPA) program was to demonstrate high-performance focal plane arrays that are widely tunable across the entire infrared (IR) spectrum (including the short-, middle- and long-wave IR bands), thus enabling “hyperspectral imaging on a chip.” This program also enabled broadband Forward Looking Infrared (FLIR) imaging with high spatial resolution. These AFPAs will be electrically tunable on a pixel-by-pixel basis, thus enabling the real-time reconfiguration of the array to maximize either spectral coverage or spatial resolution. The AFPAs will not simply be multi-functional, but rather will be adaptable by means of electronic control at each pixel. Thus, the	1.275	0.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
AFPAs will serve as an intelligent front-end to an optoelectronic microsystem. The AFPA program outcome will be a large format focal plane array that provides the best of both FLIR and Hyper-Spectral Imaging (HSI). *FY 2009 Accomplishments:* - Demonstrated AFPA prototype field using a large format array.					
Accomplishments/Planned Programs Subtotals	179.839	177.402	286.936	0.000	286.936

	FY 2009	FY 2010
Congressional Add: 3-D Technology for Advance Sensor Systems *FY 2009 Accomplishments:* - Continued 3-D device development. *FY 2010 Plans:* - Continue 3-D device development.	1.440	2.000
Congressional Add: Secure Media and ID Card Development *FY 2009 Accomplishments:* - Initiated ID card development.	0.240	0.000
Congressional Adds Subtotals	1.680	2.000

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D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	38.252	258.278	303.078	0.000	303.078	189.075	239.659	310.420	315.352	Continuing	Continuing
AIR-01: *ADVANCED AEROSPACE SYSTEMS*	38.252	258.278	303.078	0.000	303.078	189.075	239.659	310.420	315.352	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Advanced Aerospace Systems program element is budgeted in the Advanced Technology Budget Activity because it addresses high pay-off opportunities to dramatically reduce costs associated with advanced aeronautical systems and provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted. Studies conducted under this project include examination and evaluation of emerging aerospace threats, technologies, concepts, and applications for missiles, munitions, and vehicle systems.

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	87.619	338.360	0.000	0.000	0.000
Current President's Budget	38.252	258.278	303.078	0.000	303.078
Total Adjustments	-49.367	-80.082	303.078	0.000	303.078
• Congressional General Reductions		-1.082			
• Congressional Directed Reductions		-79.000			
• Congressional Rescissions	-23.825	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-23.080	0.000			
• SBIR/STTR Transfer	-2.462	0.000			
• TotalOtherAdjustments	0.000	0.000	303.078	0.000	303.078

Change Summary Explanation

FY 2009

Decrease reflects Omnibus Reprogramming action for the H1N1 vaccine development, Section 8042 rescission of the FY 2010 Appropriations Act, SBIR/STTR transfer and internal below threshold reprogramming.

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FY 2010
Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts.
FY 2011
Not Applicable

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Vulture	5.920	35.450	60.000	0.000	60.000
(U) The objective of the Vulture program is to develop and demonstrate the technology to enable an airborne payload to remain on-station uninterrupted for over five years performing intelligence, surveillance, and reconnaissance (ISR), and communication missions over an area of interest. Vulture technology enables a re-taskable, persistent pseudo-satellite capability, in an aircraft package. The technology combines the key benefits of an aircraft (flexibility & responsiveness, sensor resolution, reduced transmit/receive power, affordability) with the benefits of space assets (on-station persistence, no logistics tail, energy independence, fleet size, absence of in-country footprint). The system has potential in numerous roles: operation as a single platform, as a formation of multiple aircraft, or as a constellation providing infrastructure augmentation or recovery. The technology challenges include developing energy management and reliability technologies capable of allowing the aircraft to operate continuously for five years. The Vulture program will conduct subscale and full-scale technology maturation and demonstration activities to prove out critical technologies. Subsequently, the program will conclude with a flight demonstration near full-scale. The anticipated transition partner is the Air Force. *FY 2009 Accomplishments:* - Initiated technology maturation efforts, specifically energy storage, non-linear aeroelastic modeling of lightly loaded structures, and extreme reliability of airborne systems. - Completed Phase I, including multiple conceptual designs of Objective Systems with associated subscale demonstrators, military utility analyses, and technology maturation plans.					

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Conduct initial risk reduction analyses, testing, experiments, and demonstrations. - Initiate demonstration of component performance and reliability including energy storage, propulsion, and flight management/control systems. - Conduct Systems Requirements Review. - Initiate preliminary design of the flight demonstrator aircraft. *FY 2011 Base Plans:* - Demonstrate component performance and reliability including energy storage, propulsion, and flight management/control systems. - Perform subscale vehicle fabrication and flight demonstration and initiate long lead fabrication. - Continue subsystem and risk reduction testing. - Conduct Flight Demonstrator subsystem and component Critical Design Reviews.					
Shrike* * Formerly Stealthy, Persistent, Perch and Stare (SP2S). (U) The goal of the Shrike program is to develop a new generation of perch-and-stare micro air vehicles based on the Wasp platform. Shrike will be capable of: 1) vertical launch, 2) forward flight to a target, 3) transition from forward flight to vertical landing at the target site, 5) secure, stable attachment to its “perch,” 6) sustained perch-and-stare missions, to include data collection, and 7) re-launch from the perch and fly home. During perch-and-stare, Shrike will perform surveillance and transmit intelligence via data link to its home base. Anticipated Service users include the Army, Marines and Special Forces. *FY 2009 Accomplishments:* - Matured and integrated advanced technologies and subsystems. - Fabricated prototype systems.	5.039	5.162	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Began initial field tests with military operators. *FY 2010 Plans:* - Refine and improve prototype designs based on field testing. - Develop auto-pilot for semi autonomous landing. - Develop attachment/perching technologies that are applicable to a wide variety of terrains. - Develop and demonstrate schemes for exploitation of digital communications. - Develop tactics, techniques and procedures for Shrike missions. - Conduct field tests with second generation Shrike prototypes.					
Triple Target Terminator (T3) (U) The Triple Target Terminator (T3) program will develop a high speed, long-range missile that can engage air, cruise missile, and air defense targets. T3 would be carried internally on stealth aircraft or externally on fighters, bombers and UAVs. The enabling technologies are: propulsion, multi-mode seekers, data links, digital guidance and control, and advanced warheads. T3 would allow any aircraft to rapidly switch between air-to-air and air-to-surface capabilities. T3's speed, maneuverability, and network-centric capabilities would significantly improve U.S. aircraft survivability and increase the number and variety of targets that could be destroyed on each sortie. The program will transition to the Air Force. *FY 2010 Plans:* - Conduct studies to define T3 trade space and concepts of operation. - Initiate preliminary design studies. - Conduct risk reduction experiments and modeling to validate designs. *FY 2011 Base Plans:* - Conduct preliminary design review of T3 concepts. - Initiate T3 critical design activities.	0.000	12.146	16.908	0.000	16.908

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Integrated Sensor is Structure (ISIS)	0.000	63.400	43.400	0.000	43.400

(U) The joint DARPA/Air Force Integrated Sensor is Structure (ISIS) program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship that will address the nation's need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly integrated lightweight multi-purpose airship structure - completely erasing the distinction between payload and platform. The ISIS concept includes ninety-nine percent on-station 24/7/365 availability for simultaneous Airborne Moving Target Indicator (AMTI) (600 kilometers) and Ground-Based Moving Target Indicator (GMTI) (300 kilometers) operation; ten years of autonomous, unmanned flight; hundreds of wideband in-theater covert communications links; responsive reconstitution of failed space assets; plus CONUS-based sensor analysis and operation. A Memorandum of Agreement has been signed by DARPA and the Air Force to pursue the program objectives through to transition. The ISIS technology demonstration system transitions to the Air Force in 2013.

FY 2010 Plans:
- Conduct preliminary design review of demonstration system.
- Conduct radar system operational modeling and simulation.
- Develop and demonstrate flight dynamic controls in a lab environment.
- Demonstrate large-scale manufacturing of prototypes and initial integration.

FY 2011 Base Plans:
- Conduct critical design review of demonstration system.
- Conduct simulations to validate subsystem detailed designs.
- Conduct risk reduction testing and demonstrations of integrated subsystems.
- Manufacture airship envelope.
- Manufacture and chamber test of dual-band RF apertures.

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Vulcan	0.000	35.000	45.000	0.000	45.000
(U) The goal of the Vulcan demonstration program is to design, build, and ground test a Constant Volume Combustion (CVC) technology system that demonstrates a 20% fuel burn reduction for a ship based power generation turbine. CVC has been under development for more than a decade. Considerable progress has been made and the technology is believed mature enough to enable a dramatic new system capability. CVC, when combined with turbine engines, offers the ability to design a new class of hybrid turbine power generation engines and Mach 4+ air breathing engines. The Vulcan system will consist of a full scale CVC, a compressor, and a turbine. CVC architectures could include Pulsed Detonation Engines (PDEs), Continuous Detonation Engines (CDEs) or other unsteady CVC architectures. The CVC demonstrated in the Vulcan program would have direct application to aviation turbine engines, ship propulsion turbine engines, high mach air breathing engines, and commercial power turbine engines. In FY 2009, this program was funded in PE 0602702E, Project TT-07. Anticipated Service users include the Air Force and Navy. *FY 2010 Plans:* - Complete designs and simulations of critical components. - Conduct risk reduction demonstrations of the combustor rig, fuel system, valve rig, initiator, seals, and thermal management system rig components. - Complete CVC engine preliminary design review. - Initiate detailed design of subsystems. *FY 2011 Base Plans:* - Conduct simulations to validate subsystem detailed designs. - Conduct risk reduction testing and demonstrations of integrated subsystems including the CVC engine, inlet, and nozzle. - Begin CVC engine compressor and turbine fabrication.					
Long Range Anti-Ship Missile Demonstration (LRASM)	0.000	54.950	67.560	0.000	67.560

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) In response to emerging threats, DARPA is building on recent technology advances to develop and demonstrate standoff anti-ship strike technologies to reverse the significant and growing U.S. naval surface strike capability deficit. The Long Range Anti-Ship Missile (LRASM) program (previously funded in PE 0602702E, Project TT-03, Naval Warfare Technology) will invest in advanced component and integrated system technologies capable of providing a dramatic leap ahead in U.S. surface warfare capability focusing on organic wide area target discrimination in a network denied environment, innovative terminal survivability in the face of advanced defensive systems, and high assurance target lethality approaches. Specific technology development areas will include: robust precision guidance, navigation and control with GPS denial, multi-modal sensors for high probability target identification in dense shipping environments, and precision aimpoint targeting for maximum lethality. Component technologies will be developed, demonstrated, and integrated into a complete weapon system. The program will result in a high fidelity demonstration to support military utility assessment. A joint DARPA/ Navy effort, Navy is providing the 50% of necessary funds and is the transition partner. *FY 2010 Plans:* - Continue risk reduction testing of critical components, including seeker data collection, wind tunnel tests, and propulsion direct-connect tests. - Complete integrated system preliminary designs and hold Preliminary Design Reviews. - Conduct high fidelity independent government performance assessment of preliminary designs against key performance criteria. - Generate supporting documentation including flight test and safety plans, system engineering master plans, test and evaluation master plans, lifecycle cost estimates, and transition plans. - Commence subsystem detail designs and developmental testing. - Initiate long-lead procurements. *FY 2011 Base Plans:* - Complete subsystem detail designs and developmental testing; including seeker captive carry tests, wind tunnel tests, and propulsion free-jet test.					

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603286E: *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop hardware in the loop platforms and conduct integrated system developmental tests. - Complete integrated system detail designs and hold Critical Design Reviews. - Conduct high fidelity independent government performance assessment of final designs against key performance criteria. - Update supporting documentation including flight test and safety plans, system engineering master plans, test and evaluation master plans, lifecycle cost estimates, and transition plans. - Commence system fabrication of flight test vehicles for initial incremental test events.					
DiscRotor Compound Helicopter (U) The goal of the DiscRotor Compound Helicopter program is to design and demonstrate the enabling technologies required to develop a new type of compound helicopter capable of high-efficiency hover, high-speed flight, and seamless transition between these flight states. The aircraft will be equipped with an aft-swept wing as well as a mid-fuselage disc with extendable rotor blades, enabling the aircraft to take-off and land like a helicopter. Transition from helicopter flight to full fixed-wing flight is achieved by fully retracting the blades within the disc. An aircraft capable of long range high speed (300-400 kts) and vertical take-off and landing (VTOL)/hover will satisfy an ongoing military interest, bridging the gap in helicopter escort and insertion missions by providing survivability, mobility, and responsiveness for troop and cargo insertion. The DiscRotor enabling technologies are: variable thrust ducted prop-fans, extending telescopic rotor blades, counter torque control, and an integrated propulsion system. A prime technical objective of the DiscRotor concept is to achieve seamless reversible transition between hover and wing borne flight states. Specific objectives of the DiscRotor Compound Helicopter program include: demonstrating the feasibility of retracting the extendable blades into the disc, characterizing the flowfield environment created by a disc-rotor, demonstrating disc-rotor enabling technologies, and designing and wind tunnel testing a retractable rotor demonstrator. The anticipated transition partner is the Air Force. *FY 2009 Accomplishments:* - Completed small scale rotor (non-retractable) design and initiated fabrication.	5.342	7.940	2.210	0.000	2.210

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Conducted analysis and refinement of the vehicle conceptual approach and configurations. - Performed computational fluid dynamics analyses and predictions. *FY 2010 Plans:* - Begin to develop and fabricate 12 foot diameter large-scale extendable/retractable rotor model. - Conduct wind tunnel testing of small-scale air vehicle and static testing of small scale (non-retractable) rotor model. - Continue analysis and refinement of operational air vehicle configuration. - Continue refinement of computational fluid dynamics analyses and predictions. *FY 2011 Base Plans:* - Continue refinement of operational air vehicle configuration. - Test extensions and retractions of the large-scale rotor model in a wind-tunnel under simulated conversion conditions. - Validate DiscRotor conceptual approach, risk assessment, and definition of demonstrator requirements.					
Mode Transition (MoTr) Demonstration (U) The Mode Transition (MoTr) Demonstration program seeks to ground test a turbine-based combined-cycle (TBCC) engine using hydrocarbon fuel. The MoTr program will demonstrate transition from turbojet to ramjet/scramjet cycle and is the critical experiment required to enable reusable, air-breathing, hypersonic flight. MoTr leverages previous and on-going advances in air-breathing propulsion technology, including the Falcon Combined-cycle Engine Technology (FaCET) and the Air Force/DARPA High Speed Turbine Engine Technology Demonstration (HiSTED) program. In FY 2009, this program was funded in PE 06032867E, Project SPC-01, Space Programs and Technologies. The anticipated transition partner is the Air Force.	0.000	13.730	35.000	0.000	35.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Complete critical design of a TBCC engine model. - Complete critical design of primary testing modifications. - Initiate demonstration hardware fabrication. - Complete primary test rig modifications and checkouts. *FY 2011 Base Plans:* - Complete demonstration hardware fabrication. - Integrate demonstration hardware and test facility. - Execute ground test. - Validate and document test results.					
Persistent Close Air Support (PCAS) (U) The Persistent Close Air Support (PCAS) program will significantly increase close air support (CAS) capabilities by developing a system to allow continuous CAS availability and lethality to the supported ground commander. The enabling technologies are: manned/unmanned attack platforms, next generation graphical user interfaces (GUI), data links, digital guidance and control, and advanced munitions. PCAS will be a 'system-of-systems' approach demonstrating the ability to digitally task a CAS platform from the ground to attack multiple/simultaneous targets. PCAS will allow the Joint Tactical Air Controller (JTAC) the ability to rapidly engage multiple, moving, and simultaneous targets within his area of responsibility. PCAS's ability to digitally task a CAS platform to attack multiple/ simultaneous targets would clearly improve U.S. ground forces operations and speed of attack. The system will be designed to reduce collateral damage and potential fratricide to friendly forces. The anticipated transition partner is the Air Force. *FY 2010 Plans:* - Conduct studies to define PCAS trade space and concepts of operation.	0.000	9.000	9.000	0.000	9.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Initiate preliminary design studies. - Conduct system risk reduction experiments and modeling to validate approaches of control for PCAS targeting and coordination of fires.					
Advanced Aerospace System Concepts (U) Studies conducted under this program examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact/improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future programs or refocus ongoing work. Topics of consideration include: methods of defeating enemy anti-aircraft attacks; munition technologies to increase precision, range, endurance, and lethality of weapons for a variety of mission sets; novel launch systems; air vehicle control, power, propulsion, materials, and architectures; and payload and cargo handling systems. *FY 2009 Accomplishments:* - Performed studies of candidate technologies and developed system concepts. - Conducted modeling and simulation of system architectures and scenarios. - Developed, analyzed, and assessed initial munition concepts that would allow aircraft to rapidly switch between air-to-air and air-to-surface capabilities. *FY 2010 Plans:* - Analyze materials, designs and techniques for air systems weight reduction and structural efficiency, including complex fittings associated with propulsion and drive system housings and gearbox cases. - Conduct enabling technology and sub-system feasibility experiments.	2.297	2.500	2.000	0.000	2.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Conduct proof-of-concept demonstrations to verify technologies developed.					
Autonomous Aerial Refueling (U) The Autonomous Aerial Refueling (AAR) program will demonstrate high altitude refueling between unmanned aircraft in an operational environment. The program will leverage existing RQ-4 Global Hawk unmanned aircraft systems equipped with probe and drogue style refueling hardware and an autonomous refueling system. Specific challenges include achieving a repeatable probability of success with limited flight performance aircraft under high altitude conditions, redundant safe separation and unmanned flight operations. AAR will allow developers of high altitude long endurance aircraft to confidently employ the advantages of air refueling that have proven so vital to manned aviation. The program will foster the application of autonomy for better effectiveness, efficiency and safety in challenging battlespaces and also offers the potential for direct transition to the Global Hawk fleet. *FY 2010 Plans:* - Perform initial requirements allocation and system design. - Conduct modeling and simulation of high-altitude refueling. *FY 2011 Base Plans:* - Validate drogue performance at altitude (single-ship). - Accomplish aircraft modifications. - Complete flight test and achieve repeatable refueling performance. - Conduct operationally stressing refueling demonstration (e.g., one-week flight demo).	0.000	17.000	17.000	0.000	17.000
ArcLight (U) The ArcLight program will design, build, and flight test a long range (>2,000 nm) vehicle that carries a 100-200 lb payload(s). ArcLight is based on an SM-3 Block II booster stack, a hypersonic glider and	0.000	2.000	5.000	0.000	5.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
is capable of being launched from a Mark 41 Vertical Launch System (VLS) tube. The development of the ArcLight system will enable high speed, long range weapons capable of engaging time critical targets and can be launched from Naval surface and sub-surface assets, and Naval/Air Force air assets. Transition partners include the Navy and Air Force. *FY 2010 Plans:* - Conduct feasibility testing of novel material technology. *FY 2011 Base Plans:* - Initiate risk reduction development and test of key ArcLight enabling technologies. - Begin systems concept development.					
Heliplane (U) The Heliplane program evaluated key enabling technologies for an air vehicle that combines the vertical take-off and landing (VTOL) and low disk loading characteristics of a helicopter with the speed and efficiency characteristics of a fixed wing aircraft. Specifically, the program sought to provide a 400 mph cruise speed, a 1,000 lb payload, and an unrefueled range of 1,000 miles capability for Combat Search and Rescue (CSAR) missions. *FY 2009 Accomplishments:* - Completed the preliminary design of an alternate rotor configuration. - Completed the design of the rotor and controls. - Initiated the design of a scale model of the Heliplane and of a tip-jet nozzle.	5.384	0.000	0.000	0.000	0.000
Rapid Eye (U) The goal of the Rapid Eye program was to develop a high altitude, long endurance unmanned aircraft that could be rocket-deployed world-wide from the continental United States within 1-2 hours to perform intelligence, surveillance, reconnaissance (ISR), and communication missions. The program	14.270	0.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
examined enabling technologies such as inflatable/folding structures, lightweight reentry systems, and high-altitude propulsion. *FY 2009 Accomplishments:* - Developed Rapid Eye risk management, technology development, and system maturation plan. - Completed system conceptual design and system requirements review.					
Accomplishments/Planned Programs Subtotals	38.252	258.278	303.078	0.000	303.078

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	226.369	183.477	98.130	0.000	98.130	97.395	129.704	164.360	164.186	Continuing	Continuing
SPC-01: *SPACE PROGRAMS AND TECHNOLOGY*	226.369	183.477	98.130	0.000	98.130	97.395	129.704	164.360	164.186	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Space Programs and Technology program element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to dramatically reduce costs associated with advanced space systems and provides revolutionary new system capabilities for satisfying current and projected military missions.

(U) A space force structure that is robust against attack represents a stabilizing deterrent against adversary attacks on space assets. The keys to a secure space environment are situational awareness to detect and characterize potential attacks, a proliferation of assets to provide robustness against attack, ready access to space, the ability to neutralize man-made space environments, and a flexible infrastructure for maintaining the capabilities of on-orbit assets. Ready access to space allows the delivery of defensive systems and replenishment supplies to orbit. An infrastructure to service the mission spacecraft allows defensive actions to be taken without limiting mission lifetime. In addition, developing space access and spacecraft servicing technologies will lead to reduced ownership costs of space systems and new opportunities for introducing technologies for the exploitation of space.

(U) Systems development is also required to increase the interactivity of space systems, space-derived information and services with terrestrial users. Studies under this project include technologies and systems that will enable satellites and microsatellites to operate more effectively by increasing maneuverability, survivability, and situational awareness; enabling concepts include solar thermal propulsion, novel ion-thruster applications, payload isolation and pointing systems.

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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	226.394	200.612	0.000	0.000	0.000
Current President's Budget	226.369	183.477	98.130	0.000	98.130
Total Adjustments	-0.025	-17.135	98.130	0.000	98.130
• Congressional General Reductions		-3.435			
• Congressional Directed Reductions		-11.300			
• Congressional Rescissions	-1.144	0.000			
• Congressional Adds		1.600			
• Congressional Directed Transfers		0.000			
• Reprogrammings	7.480	0.000			
• SBIR/STTR Transfer	-6.361	0.000			
• Congressional Restoration for New Starts	0.000	-4.000	0.000	0.000	0.000
• TotalOtherAdjustments	0.000	0.000	98.130	0.000	98.130

Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2009	FY 2010
Project: SPC-01: *SPACE PROGRAMS AND TECHNOLOGY*		
Congressional Add: *Mosaic Camera Technology Transition*	0.000	1.600
Congressional Add Subtotals for Project: SPC-01	0.000	1.600
Congressional Add Totals for all Projects	0.000	1.600

Change Summary Explanation

FY 2009

Decrease reflects Section 8042 rescission of the FY 2010 Appropriations Act, SBIR/STTR transfer offset by the internal below threshold reprogramming.

FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts and internal below threshold reprogrammings offset by congressional adds (as identified above).

FY 2011

Not Applicable

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Space Surveillance Telescope (SST) (U) The Space Surveillance Telescope (SST) program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. A major goal of the SST program is to develop the technology for large curved focal surface array sensors to enable an innovative telescope design combining high detection sensitivity, short focal length, wide field of view, and rapid step-and-settle to provide orders of magnitude improvements in space surveillance. This capability will enable ground-based detection of un-cued objects in deep space for purposes such as asteroid detection and space defense missions. The Air Force will participate in the DARPA funded developmental testing of SST and then take over operation of SST as a sensor in the Air Force Space Surveillance Network. A Memorandum of Agreement (MOA) has been established with Air Force Space Command for transition. (U) In addition, the program will investigate multi-aperture SST (MASST) alternatives. It will evaluate technologies and techniques to achieve the detection/tracking sensitivity and high search rate of the SST with a more affordable and manufacturable approach, to include the combined use of multiple small telescopes to achieve the same resolution as one large one. MASST alternatives will leverage advances in complex field sensing to combine the fields from multiple small telescopes to produce high resolution images. It will determine how the complex field sensing should be performed at each sub-aperture (telescope), as well as design and develop the appropriate adaptive optics correctors, the compensation algorithms for phase differences between telescopes, and the timing and optimization algorithms needed to generate high resolution imagery in real time. The program will develop and design one or more technology demonstrators to prove the benefit and feasibility of the concepts identified. This approach will enable wider deployment of systems which can detect and track small deep space objects.	3.134	14.960	10.840	0.000	10.840

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Constructed and tested sensor subsystem. - Developed, validated, and tested software for autonomous telescope operations and data reporting. - Completed construction of telescope enclosure. *FY 2010 Plans:* - Complete processing of primary and secondary telescope mirrors. - Integrate telescope elements on site. - Initiate a survey and trade studies to assess scope of candidate MASST alternative technologies. - Perform parametric trades to define candidate architectures. - Develop algorithms for complex field reconstruction from sensor data. - Conduct experiments to determine image resolution capabilities of system prototype for near-horizontal 149km propagation. *FY 2011 Base Plans:* - Validate SST system performance and demonstrate surveillance operations. - Utilize National Security Space Office (NSSO) Space Situational Awareness (SSA) architecture to evaluate MASST alternative concepts and technologies identified against the observation gaps and needs. - Complete targeted MASST alternative trade studies and more detailed concept evaluations. - Initiate MASST alternative proof of concept technology demonstrations. - Measure selected targets over a range of atmospheric propagation paths (up to 150 km) with an array of six 0.9 m telescopes. - Develop compensation and timing algorithms for maximum resolution improvement and near-real-time processing.					
Falcon	33.000	24.170	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Falcon program objectives are to develop and demonstrate hypersonic technologies that will enable prompt global reach missions. The technologies include high lift-to-drag techniques, high temperature materials, precision navigation, guidance and control, communications through plasma, and an autonomous flight safety system. Leveraging technology developed under the Hypersonic Flight (HyFly) program, Falcon will address the implications of hypersonic flight and reusability using a series of hypersonic technology vehicles (HTVs) to incrementally demonstrate these required technologies in flight. The HTV-2 program will demonstrate enabling hypersonic technologies for future operational systems through rocket-boosted hypersonic flights with sufficient cross-range and downrange performance to evaluate thermal protection systems, aerodynamic shapes, maneuverability, and long-range communication for hypersonic cruise and re-entry vehicle applications. The Falcon program addresses many high priority mission areas and applications such as global presence and space lift. DARPA established a Memorandum of Agreement (MOA) with the Air Force for the HTV-2 program in May 2003 and with NASA in October 2004. Since 2008, the effort has been jointly funded with the Office of Secretary of Defense Global Strike program office. Falcon capabilities are planned for transition to the Air Force in FY 2011. *FY 2009 Accomplishments:* - Completed and successfully load-tested prototype aeroshell. - Completed first flight vehicle aeroshell. - Completed subsystem testing of first Minotaur IV Lite launch vehicle. *FY 2010 Plans:* - Complete Assembly, Integration and Testing (AI&T) of first HTV-2 vehicle. - Complete second flight vehicle aeroshell. - Complete AI&T of second HTV-2 vehicle. - Complete first Minotaur IV Lite Launch Vehicle. - Complete second Minotaur IV Lite Launch Vehicle. - Conduct flight test of first HTV-2 vehicle incorporating next generation hypersonic technologies.					

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Conduct flight test of second HTV-2 vehicle demonstrating increased thermal environment and cross-range capability.					
Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP)	3.750	3.312	0.000	0.000	0.000
(U) The Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) will develop advanced technologies, capabilities, and space environment characterization required to demonstrate a suite of advanced lightweight microsatellite technologies integrated into high performance microsatellites across the continuum from low earth orbit (LEO) to deep space super geosynchronous orbit (GEO) environments. The program will integrate a variety of advanced technologies, which have not been previously flight-tested, and may include: lightweight optical space surveillance/situational awareness sensors, lightweight power, chemical and electric propulsion systems, advanced lightweight structures, advanced miniature RF technology including micro crosslink and use of COTS approaches, active RF sensor technology, COTS processor and software environments, miniature navigation technologies, including the use of starfields for deep space navigation, and autonomous operations. The developed capabilities will include high thrust, high efficiency solar thermal propulsion systems that can enable responsive orbit transfer as well as provide radiation resistant high-density electrical power. The program will also explore ultra-stable payload isolation and pointing systems and components to enable advanced miniature communication systems. In addition, the program will also consider affordable, responsive fabrication and integration approaches and the possibility of networking microsatellites/modules to create a flexible architecture of assets responsive to multiple missions and threats. The anticipated transition partner is the Air Force. *FY 2009 Accomplishments:* - Conducted system design trades of appropriate technologies. - Performed mission utility assessments and feasibility studies and developed concepts of operation. *FY 2010 Plans:* - Design and develop microsatellite system concepts and integrate selected technologies.					

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Perform component and subsystem ground tests. - Conduct laboratory demonstrations of microsatellite technologies.					
System F6 (U) The objective of the System F6 program is to demonstrate the feasibility and benefits of a satellite architecture wherein the functionality of a traditional “monolithic” spacecraft is replaced by a cluster of wirelessly-interconnected spacecraft modules. Each such “fractionated” module would contribute a unique capability, e.g., computation and data handling, communications relay, guidance and navigation, payload sensing, etc., or it can replicate the capability of another module. The fractionated modules would fly in a loose, proximate cluster orbit or potentially self-assemble into an aggregate system. Critical to this architecture is a robust, system-level approach to ensuring security, integrity, and availability, while implementing authentication and non-repudiation. While delivering a comparable mission capability to a monolithic spacecraft, System F6 significantly enhances functional and programmatic flexibility and robustness, reducing risk through the mission life and spacecraft development cycle, and enabling incremental deployment of the system. The System F6 architecture provides valuable options to decision makers throughout the life cycle development of future space systems that are absent in present-day monolithic architectures. (U) The F6 program will culminate in an on-orbit demonstration of a multi-module space system incorporating the F6 Technology Package—a suite of technologies, components, and algorithms which enables autonomous multi-body orbital rendezvous and proximity operations (RPO) and real-time distributed spacecraft avionics. The F6 Technology Package will be designed such that it can be integrated with most off-the-shelf spacecraft buses to enable them to cooperatively perform a mission or missions. The on-orbit demonstration will be capable of accommodating one or more spacecraft payload modules supplied by a third-party stakeholder. Residual capability to support future payloads with the existing on-orbit infrastructure will also remain, and the infrastructure can be upgraded for an on-orbit resource capability. The utility of the F6 architecture in low earth orbit (LEO) is significantly enabled by persistent broadband connectivity to the ground which allows resource sharing between	44.675	79.000	40.000	0.000	40.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
space-based modules and terrestrial network nodes. A solution to enable high-availability, low-latency, persistent, high-bandwidth communications with LEO spacecraft will be developed in the course of the F6 program. The anticipated transition partner is the Air Force, though the architecture will have the ability to simultaneously accommodate payloads from multiple other partners including the Army and Navy. *FY 2009 Accomplishments:* - Developed a preliminary design of the on-orbit demonstration system. - Performed component and subsystem ground tests. - Conducted hardware integration laboratory (HIL) demonstrations of successively greater capability simulating 1) wireless network operating environment for fractionated satellite systems, 2) orbit propagation with real world dynamics, 3) guidance, navigation and control schemes, 4) cluster flying algorithms, and 5) distributed resource management. - Refined system design to include a detailed description of spacecraft and ground modules, subsystem-level allocation of mass, power and reliability, trade space definition for each technology, and risk analysis with mitigation schemes. *FY 2010 Plans:* - Continue refinement of the design of the on-orbit demonstration system, leading to a critical design. - Continue to perform component and subsystem ground tests. - Continue conducting HIL demonstrations, with increased fidelity provided by integration of actual flight and/or prototype hardware into the testbed. - Perform a full six-degree-of-freedom (6-DOF) long-duration, multi-body simulation with a high-fidelity disturbance model of autonomous stationkeeping and rendezvous and proximity operations (RPO) for the System F6 demonstration cluster. - Conduct a launch vehicle planning review and an information assurance design review. - Develop F6 Developer's Kit, which defines open hardware, software, and operating standards to enable third parties to interface with System F6 at the component, module, and cluster level.					

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Begin development of a persistent broadband terrestrial connectivity solution for low-earth-orbit fractionated clusters. *FY 2011 Base Plans:* - Initiate integration, assembly, and testing of flight demonstration system. - Conduct a full ground demonstration of end-to-end system capability to include: networks, wireless communication, ground command and control, and mission support. - Initiate space and launch environment testing. - Commence assembly, training and preparation for ground operations center.					
Front-end Robotics Enabling Near-term Demonstration (FREND) (U) The goal of the Front-end Robotics Enabling Near-term Demonstration (FREND) program is to develop, demonstrate, and fly robotic manipulator technologies designed to allow interaction with geosynchronous orbit (GEO)-based military and commercial spacecraft, extending their service lives and permitting satellite repositioning or retirement. Existing GEO spacecraft are outfitted with sufficient propellant to provide for needed station keeping, repositioning, and retirement maneuvers, which in many cases defines their useful mission durations. Once this propellant is expended, the vehicle is retired and, in many cases, replaced. FREND technologies can enable significant service extension to these spacecraft through re-boosting near end-of-life. (U) Recent events have significantly increased the number of objects/debris in low earth orbit (LEO), particularly in orbital planes of most interest to DoD users, causing an increased threat to safe space operations. FREND combines detailed photogrammetric and laser imaging with robotic multi-degree-of-freedom manipulators to autonomously grapple space objects not outfitted with custom interfaces. A FREND-based servicing spacecraft offers the potential for spacecraft salvage, repair, rescue, reposition, de-orbit and retirement, and debris removal. The program will examine possible solutions for all classes of LEO debris to determine the most economical technical solution set to mitigating the problem. In addition, FREND will investigate neurorobotics as a potential replacement for the baseline	10.806	19.000	11.000	0.000	11.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
suite of algorithms (e.g., arm trajectory planning, vehicle pose estimation, grapple feature identification, or compliance control) required to dock multiple robotic arms with a client spacecraft. The anticipated transition partner is the Air Force. (U) The Catcher's Mitt program is an extension of work performed under the FREND program and will address the increasing on-orbit debris collision problem faced by all U.S. space assets. Recent events have caused a dramatic increase in orbital debris. These events are part of a continuing trend that raises the probability of debris strikes with valuable U.S. space assets, possibly causing critical failures. Catcher's Mitt seeks to reduce the risk of catastrophic collision for on-orbit U.S. space assets, develop new methods for rapidly clearing important orbits after an event generates a large debris field, and develop a new method for long term clearing of debris in the most cost-effective manner. The Catcher's Mitt program will identify critical operational areas at risk as well as new solution concepts to address those risks. Solutions may include development of technologies enabling improved debris detection and tracking, improved collision prediction techniques, improved spacecraft and rocket body de-orbit/ retirement capabilities, urgent response orbit clearing, long term orbit clearing, and other novel orbital debris mitigation solutions. The program will culminate in an on-orbit demonstration of selected orbital debris remediation technologies. The anticipated transition partner is the Air Force. *FY 2009 Accomplishments:* - Developed demonstration mission. - Conducted Conceptual Design Review of FREND-based servicing spacecraft with potential mission partners. - Conducted analysis of LEO debris. *FY 2010 Plans:* - Demonstrate application of neurorobotic technology to FREND payload in "earth's gravity" environment. - Initiate a preliminary design of the FREND based servicing spacecraft.					

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
- Conduct technology and utility trade studies to model the problem, identify significant risks to operational assets, and determine possible technological solutions. *FY 2011 Base Plans:* - Develop debris remediation conceptual designs.					
Fast Access Spacecraft Testbed (FAST) (U) The goal of the Fast Access Spacecraft Testbed (FAST) program is to demonstrate a suite of critical technologies including high efficiency solar cells, sunlight concentrating arrays, large deployable structures, and ultra light weight solar arrays. These technologies enable light-weight, high efficiency, and high-power satellites of 20kW scalable to 80kW or more. The specific power goal is 130 W/Kg yielding an ultra light-weight power system of approximately 230 Kg for a 30 kW array. Combined with electric propulsion, FAST enables fast-transfer roaming satellites with nearly five times the fuel efficiency of conventional chemical propulsion. For example, FAST will permit on-demand access to any point on the geosynchronous ring or within the high-altitude, super synchronous “graveyard” (where derelict systems are regularly repositioned in order to free up orbital slots within the ring), greatly improving our ability to rapidly deploy and reposition satellites, as well as monitor the geosynchronous environment. Alternatively, FAST will permit responsive launch capabilities including deployment of small geosynchronous satellites on small launch vehicles. Scaled up systems will nearly double the effective satellite mass launched to high altitude orbits today, significantly downsizing the need for large launch vehicles. The anticipated transition partner is the Air Force. *FY 2009 Accomplishments:* - Performed detailed design, development, and ground testing of the FAST spacecraft high-power generation subsystem. - Demonstrated mechanical deployment of full-scale solar concentrator and heat rejection system in 1G environment. - Initiated design and development of the FAST demonstrator spacecraft.	11.849	13.347	3.290	0.000	3.290

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Integrate FAST high-power generation subsystem with demonstrator spacecraft. - Conduct 30-day ground test of FAST subsystems in thermal vacuum chamber including heat rejection capability. - Demonstrate mechanical deployment of full scale solar concentrator system in 1G. *FY 2011 Base Plans:* - Conduct system level testing of FAST technology to support future orbital demonstrations.					
Space Situational Awareness (SSA) & Counterspace Operations Response Environment (SCORE) (U) The goal of the Space Situational Awareness (SSA) & Counterspace Operations Response Environment (SCORE) program is to develop and demonstrate an operational framework and responsive defense application to enhance the availability of vulnerable commercial space-based communications resources. SCORE will correlate a wide range of operational support and space system ground user data to rapidly identify threat activities, propose mitigating countermeasures, and verify the effectiveness of selected responses. Critical technologies include accessing disparate sources of relevant data, model-based situational awareness, and candidate response generation and evaluation. Particular emphasis will be placed on the ability to continuously adapt to changes in defended system components and usage patterns as well as validation of SCORE system integrity. The potential transition customer is the Air Force. *FY 2009 Accomplishments:* - Conducted system trades and validated critical components. - Performed analysis of system parameters and operational procedures. *FY 2010 Plans:* - Develop algorithms and software required to integrate disparate information into a single framework.	4.800	4.400	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Integrate software environment into a suite of visualization products that provide situational awareness and decision making tools. - Conduct operational scenario testing of system, and refine algorithms and software.					
MEO Synthetic Aperture Radar (MEOSAR) (U) Synthetic Aperture Radar (SAR) integration time is currently limited by the amount of ground vehicle motion encountered during the synthetic aperture collection time. For space radar systems, this has traditionally meant that SAR had to be accomplished at low earth orbit (LEO) trajectories where the collection time would be much shorter given the high speeds of a LEO satellite. Although the specifics depend heavily on geometric considerations, medium earth orbit (MEO) SAR imaging intervals can be a factor of approximately eight times longer, compared to a LEO alternative. The longer integration times required at MEO can have a major impact on the quality of the otherwise equivalent SAR image due to the presence of internal motion within the image scene. To achieve equivalent quality imagery, the contribution of the moving targets within the image must be excised. The MEO Synthetic Aperture Radar (MEOSAR) program will develop techniques to identify moving targets and extract them from the data prior to imaging to avoid the streaking caused by their motions. The program will develop reliable automated detection of moving targets within SAR imagery using a double thresholding process in interferometric phase and amplitude. This moving target detection technique can be readily reversed to excise the moving targets from the clutter (image) background. Temporal sub-array processing will demonstrate early detection and rejection of moving targets in sub-array images. The program will develop improved motion detection and removal algorithms, demonstrate their performance on simulated and airborne data, and develop an architectural concept for a MEOSAR system. The developed technology will be transitioned to the Air Force. *FY 2009 Accomplishments:* - Performed compact test range demonstration validating system concept and algorithms. - Completed design for a potential flight demonstration system.	1.750	4.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Initiate final design plans for the flight demonstration system. - Complete subsystem technologies analysis.					
Multi-Aperture Geosynchronous (GEO) Imager (MAGI)* *Formerly Bi-Static Shield. (U) The goal of the Multi-Aperture Geosynchronous (GEO) Imager (MAGI) program is to demonstrate a segment of a world-wide millimeter wave (MMW) surveillance capability by combining radar and radio astronomy technologies and techniques. By merging interferometric receiving and correlation techniques, used by radio astronomers for decades, with high power narrow-band radar transmitter technologies, MAGI hopes to prove the capability to obtain an order of magnitude improvement in imaging resolution of GEO and near-GEO satellites. A low cost demonstration using the NASA Goldstone X-Band radar and existing radio astronomy assets (the National Radio Astronomy Organization’s Very Long Baseline Array) will be conducted to prove the concept at X-band. Based upon resolution requirements, the follow-on prototype demonstration will be at MMW (~90GHz), and will, to the greatest extent practicable, utilize COTS MMW antennas and high power (HP) narrow-band transmitters. The anticipated transition partner is the Air Force. *FY 2009 Accomplishments:* - Conducted first principles analyses of scattered signatures. - Conducted initial imaging campaign against selected GEO and near-GEO satellites. - Developed techniques to accurately recover the complex correlation functions measured during the imaging campaign and transform them into images. *FY 2010 Plans:* - Conduct additional measurement campaigns on candidate deep space objects. - Refine algorithms as required.	3.500	8.688	10.000	0.000	10.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop requirements and system concept for a prototype MAGI system. *FY 2011 Base Plans:* - Survey current state of the art and developmental MMW technologies to provide a development plan for HP sources that could be used for the Prototype Demonstration. - Initiate design of a prototype MAGI demonstration system.					
Responsive, Reliable Access to Space Program (R2A2 Space) (U) The goal of the Responsive, Reliable Access to Space Program (R2A2 Space) is to mature and demonstrate the technologies for low cost, routine and reliable access to space. Enabling technologies include composite or light weight structures, integral load bearing propellant tanks, thermal management systems, high energy density propulsion systems, advanced guidance and controls, rocket back maneuvering for a reusable first stage, and advanced upper stages. The program will validate critical technologies on the ground and, where practical, demonstrate them in flight. Where feasible, flight testing will leverage the substantial ongoing entrepreneurial private sector investments. The key program goal is demonstrating aircraft-like operability including low flight costs of less than $1M with rapid turnaround times of less than 24 hrs. *FY 2011 Base Plans:* - Conduct technology survey and selection. - Develop reusable vehicle demonstration concept(s), which may include leveraging of commercial sector investments.	0.000	0.000	7.000	0.000	7.000
Advanced Nano/Micro-Satellite Technology for Tactical Applications (U) The goal of the Advanced Nano/Micro-Satellite Technology for Tactical Applications program is to demonstrate critically needed technologies enabling a very small (nano- and micro-) satellite constellation that provides persistent tactical military applications. The U.S. Army, U.S. Air Force, intelligence community, and other potential users have identified such small satellites as a potential	0.000	0.000	4.000	0.000	4.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
technical approach for delivering affordable persistence for the tactical warfighter. By deploying large numbers of very low cost nano-satellites in distributed constellations a persistent effect can be provided to terrestrial forces. Today's technology limits the ability to do this and advances in key areas are needed to make this vision a reality. Specifically, nanosatellites lack sufficient power, communications, propulsion and imaging capacity to address many tactical needs. Key technologies include: deployable communications antennas, crosslink communications, interferometric technologies, small imaging systems, attitude control subsystems, efficient solar electric arrays, efficient maneuver capability, efficient upper stages, etc. *FY 2011 Base Plans:* - Conduct trade study of available technologies and investment opportunities. - Initiate concept design.					
XTIM (U) Leveraging technology developed in the MiDSTEP program, XTIM is an autonomous system of determining timing and positioning of space assets using X-ray pulsars and then broadcasting this information for navigation and time uses independent of, and supplemental to, GPS. XTIM autonomously calculates its position and absolute time from celestial sources. XTIM then broadcasts this information to users either on the ground or in space as a method to enhance their navigation solutions. In addition, XTIM reference data can be used to update the GPS constellation ephemerides and timing with limited or no ground support. XTIM also provides an alternative timing source that can be used as a checksum for GPS receivers to insure detection of spoofing or sophisticated jamming attacks. XTIM leverages previous work by DARPA which analytically demonstrated that X-ray pulsars could be used for navigation of space assets. XTIM will create a truly autonomous and universal time reference for military navigation and communication needs. The anticipated transition partner is the Air Force.	0.000	6.000	7.000	0.000	7.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Design an architecture utilizing XTIM to seamlessly integrate into the current pointing, navigation and timing systems allowing them to utilize the strengths of the autonomous nature of XTIM to defeat current vulnerabilities. *FY 2011 Base Plans:* - Design a geosynchronous orbit demonstration mission to be launched aboard an Evolved Expendable Launch Vehicle Secondary Payload Adaptor (ESPA) class spacecraft and proceed through preliminary design review. - Perform an X-ray beam line test of the brass board design to demonstrate feasibility of X-ray detection. - Perform an electron background rejection measurement of the brass board design to demonstrate feasibility of the geosynchronous background mitigation concept.					
Big Eye (U) Leveraging advanced membrane optics demonstrating photon sieve optics, Big Eye will enable the technology for very large aperture optics for space platforms. Big Eye utilizes the fact that photon sieve optics can achieve diffraction limited images for very large structures where only flatness is the primary concern. Big Eye will demonstrate the manufacturability of large membranes (up to 20 meters), large structures to hold the optics tight and flat, and also demonstrate the secondary optical elements needed to turn a diffraction based optic (such as photon sieve) into a wide bandwidth imaging device. Big Eye will end with a technology demonstration that significantly reduces the risk of these types of optics for flight development. The anticipated transition partner is the Air Force. *FY 2010 Plans:* - Perform system engineering to identify the system requirements which a large (20 m) optic would need to satisfy to obtain near diffraction limited images at geo-synchronous orbit.	0.000	5.000	5.000	0.000	5.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Design, construct and test an optic at least 5 m in diameter which shows how the material qualities needed for orbit could be obtained.					
Integrated Sensor is Structure (ISIS) (U) The Integrated Sensor is Structure (ISIS) program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship that will address the nation's need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly-integrated lightweight multi-purpose airship structure - completely erasing the distinction between payload and platform. The ISIS concept includes ninety-nine percent on-station 24/7/365 availability for Simultaneous Airborne Moving Target Indicator (AMTI) (600 kilometers) and Ground-Based Moving Target Indicator (GMTI) (300 kilometers) operation; ten years of autonomous, unmanned flight; hundreds of wideband in-theater covert communications links; responsive reconstitution of failed space assets; plus CONUS-based sensor analysis and operation. Beginning in FY 2010, this program will be budgeted in PE 0603286E, Project AIR-01. The ISIS technology demonstration system transitions to the Air Force in 2013. *FY 2009 Accomplishments:* - Conducted system requirements review of demonstration system. - Developed and demonstrated calibration and compensation subsystem. - Demonstrated large-scale critical integrated subsystems. - Designed radar resource controller for dynamically assigned aperture.	78.400	0.000	0.000	0.000	0.000
Mode Transition (MoTr) Demonstration	10.000	0.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Mode Transition (MoTr) Demonstration program, an outgrowth of the Falcon program, seeks to ground test a turbine-based combined-cycle (TBCC) engine using hydrocarbon fuel. The MoTr program will demonstrate transition from turbojet to ramjet/scramjet cycle and is the critical experiment required to enable reusable, air-breathing, hypersonic flight. MoTr leverages previous and on-going advances in air-breathing propulsion technology, including the Falcon Combined-cycle Engine Technology (FaCET) and the Air Force/DARPA High Speed Turbine Engine Technology Demonstration (HiSTED) programs. Beginning in FY 2010, this program will be funded in PE 0603286E, Project AIR-01, Advanced Aerospace Systems. *FY 2009 Accomplishments:* - Completed FaCET freejet testing. - Selected a turbojet from the HiSTED program. - Completed conceptual design of a TBCC engine model. - Completed facility assessment study and selected a primary facility.					
Satellite Program for Instant Depletion of Energetic Radiation (SPIDER) (U) The effects of High Altitude Nuclear Detonations (HAND) are catastrophic to satellites. HAND-generated charged particles are trapped for very long periods of time, possibly for years, oscillating between the earth's north and south magnetic poles. This enhanced radiation environment would immediately degrade low earth orbiting (LEO) spacecraft capability and result in their destruction within a few weeks. The Satellite Program for Instant Depletion of Energetic Radiation (SPIDER) program investigated technologies and techniques to rapidly mitigate the HAND-enhanced trapped radiation within days of a HAND event, before LEO spacecraft capabilities are degraded. *FY 2009 Accomplishments:* - Developed and analyzed trapped radiation mitigation concepts.	17.000	0.000	0.000	0.000	0.000
RAD Hard by Design (RHBD)	3.705	0.000	0.000	0.000	0.000

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
(U) This program developed, characterized, and demonstrated microelectronic design technologies to enable fabrication of radiation hardened electronic components using leading-edge, commercial fabrication facilities. The current mainstream approach for fabricating radiation-hardened electronics depends on specialized process technologies and dedicated foundries that serve this military market niche. While commercial semiconductor fabrication is not explicitly radiation hardened, recent trends in deeply scaled fabrication such as very thin oxides, trench isolation, and multiple levels of metal are resulting in semiconductor devices that are inherently more tolerant of radiation than older generations. This program pursued development of design-based technologies to enable pure commercial fabrication technologies to attain radiation hardened electronics equivalent to those from the dedicated foundries. The design technology developed under the Radiation Hardening by Design (RHBD) program is planned for transition to the Air Force and to the Defense Threat Reduction Agency (DTRA) at the end of Phase II. Specific design libraries for hardened circuits will transition through the defense electronics design industry, which are being supported largely by DTRA and the Air Force. *FY 2009 Accomplishments:* - Fabricated and tested “final” RHBD demo integrated circuits (ICs) chosen in FY 2008 (90 nm complementary metal oxide semiconductor (CMOS) technology). - Completed investigation of RHBD efficacy in 65 nm CMOS technology. - Completed investigation of RHBD efficacy in silicon on insulator (SOI) technology.					
Accomplishments/Planned Programs Subtotals	226.369	181.877	98.130	0.000	98.130

	FY 2009	**FY 2010**
Congressional Add: Mosaic Camera Technology Transition *FY 2010 Plans:* - Continue research into the transition of mosaic camera technology.	0.000	1.600

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C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Adds Subtotals	0.000	1.600

D. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• Falcon: *OSD*	11.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
• Space Surveillance Telescope: *USAF*	1.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	192.686	194.094	197.098	0.000	197.098	151.274	157.386	150.143	149.334	Continuing	Continuing
MT-07: *CENTERS OF EXCELLENCE*	7.000	7.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	63.439	77.963	64.496	0.000	64.496	44.150	50.390	50.037	50.095	Continuing	Continuing
MT-15: *MIXED TECHNOLOGY INTEGRATION*	122.247	109.131	132.602	0.000	132.602	107.124	106.996	100.106	99.239	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Advanced Electronics Technology program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and processing technologies for the production of various electronics and microelectronic devices, sensor systems, actuators and gear drives that have military applications and potential commercial utility. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements.

(U) The MicroElectroMechanical Systems (MEMS) and Integrated Microsystems Technology project is a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems to address issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. The MEMS project has three principal objectives: the realization of advanced devices and systems concepts, the development and insertion of MEMS into DoD systems, and the creation of support and access technologies to catalyze a MEMS technology infrastructure.

(U) The goal of the Mixed Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems. These ‘wristwatch size’, low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. The chip assembly and packaging processes currently in use produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration of mixed technologies to form

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batch-fabricated, mixed technology microsystems ‘on-a-single-chip’ or an integrated and interconnected ‘stack-of-chips’. The ability to integrate mixed technologies onto a single substrate will increase performance and reliability, while driving down size, weight, volume and cost.

(U) The Centers of Excellence project provided funding to finance the demonstration, training and deployment of advanced manufacturing technology at Marshall University and the MilTech Extension program.

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	199.504	205.912	0.000	0.000	0.000
Current President's Budget	192.686	194.094	197.098	0.000	197.098
Total Adjustments	-6.818	-11.818	197.098	0.000	197.098
• Congressional General Reductions		-0.813			
• Congressional Directed Reductions		-33.005			
• Congressional Rescissions	-3.798	0.000			
• Congressional Adds		7.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	2.585	0.000			
• SBIR/STTR Transfer	-5.605	0.000			
• Congressional Restoration for New Starts	0.000	15.000	0.000	0.000	0.000
• TotalOtherAdjustments	0.000	0.000	197.098	0.000	197.098

Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2009	FY 2010
Project: MT-07: *CENTERS OF EXCELLENCE*		
Congressional Add: *Advanced Flexible Manufacturing*	7.000	7.000
Congressional Add Subtotals for Project: MT-07	7.000	7.000
Project: MT-15: *MIXED TECHNOLOGY INTEGRATION*		
Congressional Add: *Center for Autonomous Solar Power*	4.000	0.000
Congressional Add: *Hybrid Power Generation System*	1.200	0.000
Congressional Add: *Ultra Low Power Electronics for Special Purpose Computers/Ubiquitous Computing*	1.600	0.000

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Congressional Add Details ($ in Millions, and Includes General Reductions)

	FY 2009	FY 2010
Congressional Add Subtotals for Project: MT-15	6.800	0.000
Congressional Add Totals for all Projects	13.800	7.000

Change Summary Explanation

FY 2009

Decrease reflects SBIR/STTR transfer and Section 8042 rescission of the FY 2010 Appropriations Act offset by internal below threshold reprogramming.

FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts offset by the FY 2010 Congressional Restoration for New Starts.

FY 2011

Not Applicable

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MT-07: *CENTERS OF EXCELLENCE*	7.000	7.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University. The Byrd Institute provides both a teaching facility and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training emphasizes technologies to significantly reduce unit production and life cycle costs and to improve product quality.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Advanced Flexible Manufacturing *FY 2009 Accomplishments:* - Assessed the Institute for Advanced Flexible Manufacturing's performance and worked toward transitioning from DoD to state/private support. *FY 2010 Plans:* - Continue to Assess the Institute for Advanced Flexible Manufacturing's performance and work toward transitioning from DoD to state/private support.	7.000	7.000
Congressional Adds Subtotals	7.000	7.000

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010

APPROPRIATION/BUDGET ACTIVITY	**R-1 ITEM NOMENCLATURE**	**PROJECT**
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	63.439	77.963	64.496	0.000	64.496	44.150	50.390	50.037	50.095	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The MicroElectroMechanical Systems (MEMS) and Integrated Microsystems Technology program is a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those used to make microelectronic devices, MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale power and actuation systems as well as microscale components that survive harsh environments. The microfluidic molecular systems program will develop automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules to perform tailored analysis sequences to monitor environmental conditions, health hazards and physiological states.

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) chemical reactions on chip; 5) electromechanical signal processing; 6) analytical instruments; and 7) thermal management.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Harsh Environment Robust Micromechanical Technology (HERMIT) (U) The Harsh Environment Robust Micromechanical Technology (HERMIT) program is developing micromechanical devices that can operate under harsh conditions (e.g., under large temperature excursions, large power throughputs, high g-forces, corrosive substances) while maintaining	6.495	3.600	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
unprecedented performance, stability, and lifetime. Micromechanical RF switches are of particular interest, where sizable power throughputs and impacting operation constitute harsh operational environments. Other applications such as vibrating resonator reference tanks, gyroscopes, and accelerometers are also of interest. Among the HERMIT implementation approaches deemed likely to succeed, two are of the most interest: 1) wafer-level encapsulation or packaging strategies based on MicroElectroMechanical systems (MEMS) technology that isolates a micromechanical device from its surroundings while maintaining a desired environment via passive or active control; and 2) material and design engineering strategies that render a micromechanical device impervious to its environment with or without a package (if possible). A key approach in this program that should allow orders of magnitude power savings is to selectively control only the needed micro-scale environment or volume via MEMS-enabled isolation technologies. The success of this program should enable a myriad of strategic capabilities including lower cost, more complex phased array antennas for radar applications; tiny frequency references with long- and short-term stabilities that greatly extend the portability of ultra-secure communications; and micro-scale inertial measurement units with bias stabilities approaching navigation-grade. The HERMIT program is anticipated to transition via industry to phased array antenna, reconfigurable communication front-end, seeker, and steerable aperture programs being developed by the Army, Navy, and Air Force, as well as to inertial navigation systems and Joint Tactical Radio System (JTRS) communications needed by these Services. *FY 2009 Accomplishments:* - Demonstrated micromechanical devices (e.g., RF switches, vibrating resonators) fully integrated together with environment isolating measures (including circuits, if any) that maintain unprecedented performance, stability, and reliability, even under harsh environments. - Demonstrated high yield MEMS RF switching component technologies that result in test devices that can operate for at least 100 billion switching cycles. Yield goals were to attain a 95% confidence that 99% of tested devices met 100 billion cycles. - Implemented parallel measurement set-up to increase test throughput. - Initiated efforts for demonstrating the performance of RF switches in relevant radar applications.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Demonstrate hermetic packaging technology for advanced MEMS inertial gyroscopes and accelerometers.					
MEMS Exchange (U) The MEMS Exchange program seeks to provide flexible access to complex MicroElectroMechanical systems (MEMS) fabrication technology in a wide variety of materials and to a broad, multi-disciplinary user base via the MEMS Exchange service. A major goal of the effort is to ensure self-sustained operation of MEMS Exchange after the end of the program by adding several process modules to the existing repertoire and increasing the number of processes run per year to raise revenues to the point of self-sufficiency. Among the future payoffs of this program is the establishment of an accessible infrastructure for low or medium volume production of MEMS-enabled products for DoD applications. The goal of the MEMS Exchange program is to provide MEMS fabrication services to all levels of industry and academia in support of Army, Navy, Air Force, and other DoD requirements without further DARPA sponsorship. *FY 2009 Accomplishments:* - Inserted MEMS technology into three DoD applications using MEMS Exchange as the fabrication vehicle. *FY 2010 Plans:* - Implement new state-of-the-art technical unit process capabilities to achieve greater effectiveness for creating MEMS devices, including electron-beam lithography, mixed transistor and MEMS process modules, and general purpose MEMS hermetic packaging. - Initiate new quality control efforts to achieve higher reliability in manufacturing. *FY 2011 Base Plans:* - Optimize process cost efficiencies by increased marketing of MEMS Exchange capability.	2.467	2.376	1.600	0.000	1.600

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Improve self-sufficiency by providing a higher value to program users by improved yield and lower manufacturing costs.					
Low Power Micro Cryogenic Coolers (MCC) (U) The Low Power Micro Cryogenic Coolers (MCC) program will attain superior performance in micro-scale devices (e.g. Low Noise Amplifier (LNA's) IR detectors, RF front-ends, superconducting circuits) by cooling selected portions to cryogenic temperatures. The key approach in this program that should allow orders of magnitude power savings is to selectively cool only the needed volume/device via MEMS-enabled isolation technologies. Such an approach will benefit a large number of applications where performance is determined predominately by only a few devices in a system, e.g., communications where the front-end filter and LNA often set the noise figure; and sensors, where the transducer and input transistor in the sense amplifier often set the resolution. Additionally, this program will develop a high performance chip-scale micropump for efficient fluid distribution within various microsystems. MEMS technology will also be instrumental for achieving micro-scale mechanical pumps, valves, heat exchangers, and compressors, all needed to realize a complete cryogenic refrigeration system on a chip. Transition of this technology is anticipated through industry, which will incorporate elements of the technology in current and future weapon system designs. *FY 2009 Accomplishments:* - Integrated micro cooler components together with sufficiently isolated devices to-be-cooled to yield a single chip system consuming very little power. - Developed methods to increase compression ratio and pump speeds to MEMS scales. - Decreased size of on-chip vacuum pumps. *FY 2010 Plans:* - Improve MEMS-derived thermal isolation microstructures. - Develop improved thermoelectric materials for integration with existing and future MEMS. - Demonstrate turbomolecular pumping.	8.711	8.223	6.533	0.000	6.533

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate micromechanical vacuum on a chip with less than 1 Torr operating pressure. *FY 2011 Base Plans:* - Develop MEMS-based analytical instruments of <10^-6 Torr with a sampling flow rate with on-chip vacuum conditions.					
Microsystem Integrated Navigation Technology (MINT) (U) The Microsystem Integrated Navigation Technology (MINT) program is developing technology for precision inertial navigation coupled with micro navigation aiding sensors. The MINT program will develop universally reconfigurable microsensors (e.g., for magnetic fields, temperature, pressure) with unmatched resolution and sensitivity. These devices will use the latest in MEMS and photonic technologies to harness perturbations in atomic transitions as the sensing and measuring mechanisms for various parameters. Program transition will occur through industrial performers into future DoD platforms. *FY 2009 Accomplishments:* - Reduced power and volume requirements. - Developed technologies to harvest power through energy scavenging. *FY 2010 Plans:* - Develop and demonstrate micro-fabrication technologies for creating new classes of MEMS navigation instruments that can be used for achieving high accuracy, GPS free navigation using zero-velocity updating. *FY 2011 Base Plans:* - Initiate measurements and testing of initial MINT navigation prototypes at DoD laboratories to confirm navigation properties and accuracies.	5.991	6.687	6.549	0.000	6.549
Integrated Primary Atomic Clock (IMPACT)	7.970	6.916	7.796	0.000	7.796

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Integrated Primary Atomic Clock (IMPACT) program will extend the accuracy of Chip Scale Atomic Clock (CSAC) by exploiting the precision of nuclear particle transport. The concept of beam clock has been known at least since the 1960's but has not been widely pursued due to the difficulty in containing a large volume of xenon gas. This problem will be addressed by going to the micro-scale. Miniaturization of the conventional beam clocks with major innovations are possible due to microscale implementation – microscale xenon atom source, micromachined permanent magnets, and micromechanical atom flux detectors. This approach will not only improve the stability over existing CSAC but will further reduce the required power. This technology will be transitioned into DoD systems through innovative companies, including performers under the Chip-Scale Atomic Clock program. *FY 2009 Accomplishments:* - Determined pressure measurement in presence of high magnetic field with MEMS pressure sensors. - Identified retrace drifts and reduced zero aging of atomic frequency. *FY 2010 Plans:* - Initiate technology development efforts for demonstrating a complete physics package for an advanced miniaturizable atomic clock that can interrogate gaseous atoms and does not suffer from light shifts and buffer gas shifts that usually limit the use of hyperfine transition frequencies for applications to clocks. *FY 2011 Base Plans:* - Initiate fabrication technologies to develop an advanced approach that will reduce size, weight and power of physics package to enable dramatic reductions in the size and power of the physics package along with the entire integrated timing assembly.					
Nano-Electro-Mechanical Computers (NEMS) (U) The goal of the Nano-Electro-Mechanical Computers (NEMS) program is to develop nanoscale mechanical switches and gain elements integrated intimately with complementary metal-oxide	3.916	6.918	6.829	0.000	6.829

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
semiconductor switches. One mechanical switch per transistor will enable the transistor to operate at near zero leakage powers, enabling pico or femtowatt standby operation. The program will also develop mechanical gain elements using physical effects such as giant magnetoresistance, buckling, electromechanical phase transitions, van der Waals forces, and Casimir forces to enable very low-noise, high-frequency amplifiers for low-power, low-noise analog signal processing. Mechanical power supplies and mechanical vibrating clocks could facilitate production of electronics that are less susceptible to electromagnetic pulse attacks. Integrating nanomechanical elements in direct bandgap materials will circumvent problems of gate oxide stability, allowing fast logic with optics functionality. This program will transition into DoD systems via industrial program performers. *FY 2009 Accomplishments:* - Developed NEMS switches in direct bandgap materials to enable optical functionality with switches. *FY 2010 Plans:* - Demonstrate NEMS devices and technologies for microcontroller building blocks - adders, counters, memories, that can operate at very high temperatures. *FY 2011 Base Plans:* - Demonstrate capability to produce analog mechanical components such as operational amplifiers that can operate with 100X lower input noise than conventional approaches.					
Information Tethered Microscale Autonomous Rotary Stages (ITMARS) (U) Early MEMS work had demonstrated many ways of realizing rotating micromotors, and in fact had been the source of major popular interest in the field of micromachines. However, the unique capability to precisely rotate micromachined structures in a controllable manner has been under-utilized in MEMS systems. Although the use in micromotors for optical and mechanical switches has been demonstrated, most applications passively use the structures fabricated into the rotary stage. To date there is no technology able to transmit power and signals to these tiny stages from the substrate on	2.907	4.452	4.993	0.000	4.993

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
which they are rotating. This program will explore ways at pushing the envelope by engineering ways of coupling power and signals to a rotating MEMS stage, and measuring its position with much higher accuracy then possible at the macroscale. With this capability, arrays of rotating 100-1000 micron diameter stages could carry various sensors that can be aimed at any azimuth and inclination, and can be rotated 360 degrees for cancelling angle dependent biases. Examples of sensors that might utilize this capability include microphones, antennas, radiation sensors, etc. Although many of these sensors exist, by adding the rotating stage functionality without increase in sensor/system size, weight, and power, one can really see the benefit of integrating MEMS with traditional sensors. The program will transition via industry performers. *FY 2009 Accomplishments:* - Initiated efforts to implement power and information to microscale rotating stages, for various applications. *FY 2010 Plans:* - Develop prototype applications. - Reduce bias levels in sensors, increase directivity in directional sensors, and achieve mechanical phased arrays. *FY 2011 Base Plans:* - Integrate micro rotating stages with integrated circuits (ICs) to achieve 1-cubic centimeter (cc) microsystem.					
Chip-Scale Micro Gas Analyzers (U) The Chip-Scale Micro Gas Analyzers program is utilizing the latest microelectromechanical systems (MEMS) technologies to implement separation-based analyzers (e.g., gas chromatographs, mass spectrometers, poly-chromator-like devices) at the micro-scale to greatly enhance the selectivity of sensors to specific species, and thus, enable extremely reliable, remote detection of chemical/	9.553	6.433	7.761	0.000	7.761

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
biological agents. The use of MEMS technology will also increase analysis speed and made possible the operation of such complex analyzer systems at extremely low power levels-perhaps low enough for operation as autonomous, wireless sensors. The many challenges in this program include the exploration and realization of micro-scale preconcentrator approaches, stacked gas columns, multiple sensor arrays, ionizers, vacuum pumps, and vacuum packaging. The success of this program will yield sensors substantially more selective than conventional sensors, again, making them particularly suitable for detection and identification of airborne toxins. This program will also develop micro-resonators that accept and isolate narrow channels of the radio spectrum. This research would enable communication receivers that operate under any communication standard around the world. The Chip-Scale Gas Analyzers program is transitioning via industry to Chemical Warfare Agents (CWA) detector programs being developed by the Defense Threat Reduction Agency (DTRA) and the Army Soldier and Biological Chemical Command (SBCCOM). *FY 2009 Accomplishments:* - Demonstrated advanced methods for making micromechanical sensor elements species sensitive (e.g.,combinations of absorption spectroscopy and resonators coated with species-and-light sensitive films). - Implemented fully functional, MEMS-enabled gas separation analyzers with power consumptions small enough for autonomous, remote operation and control electronics integrated directly. - Focused on single channel at 3 GHz. - Initiated effort at 60 channels with 30 KHz spacing. *FY 2010 Plans:* - Fabricate single nanoresonator with Quality Factor Q > 100,000 and operating frequency greater than 3 GHz. - Improve rejection of unwanted signals while minimizing impedance. - Match resonators to analog-to-digital converters.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Continue to develop resonators with high quality (>30,000) at high frequencies.					
Thermal Management Technologies (TMT) (U) The goal of the Thermal Management Technologies program is to explore and optimize new nanostructured materials and other recent advances for use in thermal management systems. Innovative research is underway to go beyond evolutionary thermal management systems. Modem, high-performance heat spreaders, which use two-phase cooling, are being developed to replace the copper alloy spreaders in conventional systems. Enhancing air-cooled exchangers by reducing the thermal resistance through the heat sink to the ambient, increasing convection through the system, improving heat sink fin thermal conductivity, optimizing and/or redesigning the complimentary heat sink blower, and increasing the overall system (heat sink and blower) coefficient of performance is another thrust of this program. Another element of this effort is focused on novel materials and structures that can provide significant reductions in the thermal resistance of the thermal interface layer between the backside of an electronic device and the next layer of the package, which might be a spreader or a heat sink. The Thermal Management Technologies program is an aggregation of: Thermal Ground Plane (TGP), Microtechnologies for AirCooled Exchangers (MACE), Nano Thermal Interfaces (NTI) and Active Cooling Modules (ACM) technology research. Technology will be inserted through DoD industrial firms into future DoD systems. *FY 2009 Accomplishments:* - Demonstrated the performance benefits of an integrated high-performance thermal materials and substrates through refining of wick materials and tuning the composition of the casing. - Fabricated and tested a 'single-fin' heat sink device. - Performed experiments to verify properties and performance.	15.429	32.358	22.435	0.000	22.435

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Investigate active cooling of electronic devices using techniques such as thermoelectric coolers, sterling engines, etc. - Demonstrate a full-performance high-thermal conductivity substrate with enhanced thermal conductivity, hermeticity, and lifetime in a scaled-up 20 cm x 10 cm x <1mm sample. - Scale up prototype air-cooled exchangers to a large, full-format heat sink. - Develop and demonstrate full-sized heat sink using air-cooled exchanger technologies. *FY 2011 Base Plans:* - Deliver fifty sample thermal conductivity substrate components for testing and insertion into DoD systems. - Design and build modules with all interfaces that demonstrate ACM benefits. - Reduce junction temperature for electronic devices. - Further increase electronic device power. - Increase device reliability. - Identify DoD insertion opportunities, revise testing and reliability activities to meet insertions, and provide testing samples. - Modify parameters of specific DoD insertions.					
Accomplishments/Planned Programs Subtotals	63.439	77.963	64.496	0.000	64.496

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

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E. Performance Metrics

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

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MT-15: *MIXED TECHNOLOGY INTEGRATION*	122.247	109.131	132.602	0.000	132.602	107.124	106.996	100.106	99.239	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The goal of the Mixed Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems. These ‘wristwatch size’, low-cost, lightweight and low power microsystems will improve the battlefield awareness, security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: microelectromechanical systems (MEMS), microphotonics, microfluidics and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, and requires fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration of mixed technologies to form batch-fabricated, mixed technology microsystems ‘on-a-single-chip’ or an integrated and interconnected ‘stack-of-chips’.

(U) The field of microelectronics incorporates micrometer/nanometer scale integration and is the most highly integrated, low-cost and high-impact technology to date. Microelectronics technology has produced the microcomputer-chip that enabled or supported the revolutions in computers, networking and communication. This program extends the microelectronics paradigm to include the integration of heterogeneous or mixed technologies. This new paradigm will create a new class of ‘matchbook-size’, highly integrated device and microsystem architectures. Examples of component-microsystems include low-power, small-volume, lightweight, microsensors, microrobots and microcommunication systems that will improve and expand the performance of the warfighter, military platforms, munitions and Unmanned Air Vehicles (UAVs).

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using ‘standard’ processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and ‘multiple-chip-scale’ packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave technologies. For example, a mixed-technology microsystem using integrated microfluidics, MEMS, microphotonics, microelectronics and microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment. The ability to integrate mixed technologies onto a single substrate will drive down the size, weight, volume, and cost of weapon systems while increasing their performance and reliability.

B. Accomplishments/Planned Program ($ in Millions)

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Adaptive Photonic Phased Locked Elements (APPLE) Phase II	9.521	11.182	20.000	0.000	20.000
(U) The Adaptive Photonic Phase-Locked Elements (APPLE) Phase II program will develop ultra-compact, electronically-steerable, high power optical phased arrays, with each array element driven ultimately by a 3 kW fiber laser amplifier being developed in the Revolution in Fiber Lasers (RIFL) program. Each array element will contain an adaptive optics system to correct for the beam spreading effects of atmospheric turbulence and will have a clear aperture dimension of 2.5 cm to allow compensation for even the strongest atmospheric turbulence encountered in ground-to-air, air-to-air, and ground-to-space applications with only tip/tilt control. This conformal optical phased array technology is scalable in both power and total aperture size by adding additional elements to the array. The high power optical phased array technology being developed in this program will serve a broad spectrum of applications including laser communications, broad-area search and track, Identification of Friend or Foe (IFF), missile seeker negation, and at high power, surgical kill of strategic and tactical targets with minimal collateral damage. Technology will transition to Industry. *FY 2009 Accomplishments:* - Demonstrated high power combined output of multiple (7) small individual apertures. *FY 2010 Plans:* - Demonstrate atmospheric compensation in the real atmosphere at low powers. - Develop a fiber-array testbed with twenty-four phase-locked channels for analysis of potential scaling limitations on fiber-array high energy laser systems. *FY 2011 Base Plans:* - Design 7-element optical phased array with array elements suitable for 1 kW coherently combinable fiber laser amplifiers. - Design experiments to determine the maximum number of array elements that can be coherently combined in a target-in-the-loop configuration as a function of noise in each of the array channels.					
Visible/Short Wave IR - Photon Counting	3.054	2.083	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Visible/Short Wave IR - Photon Counting program will develop imaging over a broad spectral band at extremely low levels of ambient illumination to provide a unique capability for remote sensing, unattended sensors, and pay-loads for autonomous ground and air platforms. Recent innovations in solid state imaging devices, including parallel processing at the pixel level and novel read read-out technology, can contribute to development of a new class of sensors, which can create an image with only a few photons per pixel, exceeding performance of current low light level imagers. The direct conversion of low light level information into an electronic format provides access to a suite of signal processing, image enhancement and communications techniques not available with current low light level imaging devices. This program will transition via industry for ultraviolet to infrared imaging applications. *FY 2009 Accomplishments:* - Demonstrated single photon counting devices for ultra low noise imaging. - Designed and built prototype real-time processor. *FY 2010 Plans:* - Demonstrate real-time processor and interface with an existing photon counting camera.					
Dual-Mode Detector Ensemble (DUDE) (U) The Dual-Mode Detector Ensemble (DUDE) demonstrates the integration of an uncooled long wave infrared sensor (LWIR) (8-12 microns) with a sensor that operates in the Visible/Near Infrared/SWIR (VNS) (0.4-1.6 microns) spectral range. The integration of this combined day/night focal plane with the broad spectral band flat-format optics will realize a compact day/night rifle sight system. The combined sensor will provide the soldier with the ability to utilize aiming lights registered with the thermal image, see through windows with the reflected light sensors, identify people at night, and see targets on the battlefield designated from other sources, while reducing the logistics burden and weight they have to carry. These together would be a major paradigm shift in the technology. The demonstration array will be a large format long wave infrared array operating at room temperature with four reflected light pixels	5.772	9.834	5.543	0.000	5.543

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
for each long wave pixel, and evaluated for rifle sight applications. The technology will transition via industry upon successful completion of the program. *FY 2009 Accomplishments:* - Reduced dark counts for room temperature operation. - Demonstrated integrated functions, such as day/night imaging with covert signal detection. *FY 2010 Plans:* - Build 640x512 infrared array integrated with a Visible/Near-IR/Short-wave IR (VNS) array. - Demonstrate VNS array with the pixels meeting dark current of 50 na/cm^2 at 10 degrees C. - Demonstrate aiming lights co-registered with the infrared array. *FY 2011 Base Plans:* - Build 640x512 long wave infrared array with 20 micrometer unit cell, with four VNS pixels per unit cell. - Demonstrate VNS array with the pixels meeting dark current of 20 na/cm^2 at 10 degrees C. - Demonstrate man-recognition range at 1 km.					
Hemispherical Array Detector for Imaging (HARDI) (U) The objective of the Hemispherical Array Detector for Imaging (HARDI) program is to exploit the benefits of the hemispherical imaging surface. The basic idea behind the program is that a detector array can be fabricated on a hemispherical substrate using materials such as organic/inorganic semiconductors and that this array can be combined with a single lens to produce a wide field of view, small form factor camera. Organic materials have been shown to have good electronic and optoelectronic properties including light emission and detection. Furthermore, in-plane organic/ inorganic transistors can be incorporated for pre-processing of images. This program will transition to eventual DoD systems through a demonstration of an array prototype developed by industrial contractors.	2.109	2.328	2.754	0.000	2.754

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed improved materials for Visable-Near IR and Shortwave IR. - Demonstrated a curved focal plane array. *FY 2010 Plans:* - Develop novel photodetector materials for the spectral range 400-1900 nanometers (nm). - Demonstrate a 16,000 pixel array on a 2.5 cm radius hemispherical substrate. - Explore manufacturing techniques amenable to producing hemispherical array detectors with high reproducibility. *FY 2011 Base Plans:* - Demonstrate a prototype 1 megapixel, 1 cm radius hemispherical focal plane array for the spectral range of 400-1900 nm. - Demonstrate a prototype f/1.4 camera with a 120 degree field of view with high reliability.					
Photon Trap Structures for Quantum Advanced Detectors (P-SQUAD) (U) The objective of Photon Trap Structures for Quantum Advanced Detectors (P-SQUAD) is to develop technologies for fabrication of multi-stacked and multi-functional nano-pillar materials structures for various new and improved devices. The main objective is to develop a process technology that allows fabrication of nano-pillar stacked architectures of at least three different semiconductor materials for multi-spectral infrared (IR) detector technology. This technology will transition via the program's industrial performers. *FY 2009 Accomplishments:* - Fabricated 16 x 16 detector arrays using nano-pillar arrays. - Validated P-SQUAD structure design characteristics using experimental and theoretical models.	6.061	12.520	14.668	0.000	14.668

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Demonstrate a 640 x 480 array that is fully integrated with readout processor. - Design and validate P-SQUAD integrated array. *FY 2011 Base Plans:* - Demonstrate an integrated 640 x 480 imaging camera prototype using P-SQUAD devices and fully characterize. - Validate PT-SQUAD integrated array design. - Deliver four fully characterized 640 x 480 focal plane arrays.					
Nyquist-Limited Infrared Detectors (NIRD) (U) The Nyquist-Limited Infrared Detectors (NIRD) program develops high density, long-wave infrared (LWIR) arrays and signal processing to improve capability to image through scattering media such as dust and sand, known as brownout, fog, snow storms, and to enhance situational awareness needed for aircraft navigation. The LWIR provides advantages in imaging through the dust clouds created in helicopter landing especially in desert areas. This obscurant penetration capability of LWIR imaging can be significantly improved when the pixel size is reduced to preserve high frequency information, while at the same time, a practical size optical aperture is maintained with approximately F/1 optics. The obscurant penetration capability of the LWIR focal plane array (FPA) can be further enhanced with signal and imaging processing. The low frequency pedestal in the image caused by the obscurant must be reduced to increase image contrast and the effective dynamic range. The small pixel FPA presents unique challenges in detector design and fabrication and in the interconnection of the detector array to the read-out integrated circuit (ROIC). The origin of noise currents in the detector must be understood and characterized, especially the role of surface currents in the small pixel devices. The method of interconnection must be compatible with large arrays of small pixel elements, achieve a low contact resistance, and reliably interconnect at each pixel across the array. This program will transition via industry upon successful completion.	4.218	10.372	7.724	0.000	7.724

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Developed new detector approaches for high pixel density with passivation processes to control surface leakage, which will dominate small detectors. - Demonstrated test structures with detector size approaching two microns and illustrated contact method to small pixel structure. - Conducted feasibility study incorporating the results from the static runway measurements, outside data collection sources, and dynamic flight tests. - Developed requirements to support the development of a high resolution sensor pertinent to limited visibility flight operations. *FY 2010 Plans:* - Demonstrate LWIR detectors, with a size of 5 micrometers, operating at 80K with dark current less than 0.5ma/cm^2. - Achieve 10 x 10 LWIR array with 5 micrometer pixels interconnected to silicon read-out with interconnect resistance less than 5 ohm. *FY 2011 Base Plans:* - Achieve 256x256 array with 5 micrometer pixels showing 90% of pixels at dark current goal. - Perform high-density interconnection between detector and read-out circuit with less than 10% change in interconnect resistance after 1000 cycles.					
Advanced Photonic Switch (APS) (U) The objective of the Advanced Photonic Switch (APS) program is to develop a technology for creating on-chip, photonic switching devices which can be fabricated in a silicon-compatible process. Most high performance photonic switching devices are fabricated with compound semiconductors, but silicon manufacturing technologies now offer potential advantages due to the great precision being driven by commercial mainstream markets for microelectronics. This program is pursuing advanced technologies that will take full advantage of those commercial capabilities but will exploit them to	1.380	5.468	3.367	0.000	3.367

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
produce photonic devices that maximize switching speed, minimize device power dissipation and transmission losses, small area, and decreased sensitivity to ambient temperature variations. The photonic switches developed in this program will be spectrally broad-band, capable of simultaneously switching multiple, high bit-rate wavelength channels, and scalable to complex port switches. The switching devices developed in APS will benefit low power, high bandwidth, low latency, photonic communications networks, thereby benefiting a broad array of U.S. Department of Defense (DoD) problems and the larger U.S. National interests in network-based activities. APS will transition to industry. *FY 2009 Accomplishments:* - Completed fabrication of prototype Number of Bits per Second (NOBS) devices to create a 2x2 array. - Designed, fabricated, and tested silicon complementary metal-oxide semiconductor (CMOS) driver circuits that can be integrated with NOBS. *FY 2010 Plans:* - Enhance APS fabrication technologies and design approaches to improve the NOBS devices and integrated assemblies. *FY 2011 Base Plans:* - Develop and implement new design and fabrication technologies for improving the performance of the NOBS devices and integrated assemblies into switches.					
COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) (U) The COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) program goal is to realize the fundamental performance potential of the resonant fiber optic gyro (RFOG) in combination with bandgap optical fiber (BGOF), ultra-stable compact lasers, phase conjugate elements (PCEs), and silicon optical benches: a compact ultra-stable gyro for absolute reference applications. The COUGAR	5.761	10.004	12.716	0.000	12.716

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
gyro will have a practical and typical size (~ 4 inch diameter) featuring bias stability and sensitivity (or angle random walk), which is more than 100 times better than state-of-the-art gyroscopes. This program will transition via industry. *FY 2009 Accomplishments:* - Developed purely single-polarization low-loss, low glass-content BGOF. - Demonstrated compact narrow line-width single-frequency laser technology with ultra-low jitter and the capability of extremely linear frequency scanning. - Developed resonator-ready (low-loss) PCEs for mitigating residual non-linear Kerr Effect errors and relaxing tolerances on laser intensity stabilization requirements. - Developed silicon optical bench technology for optical ruggedization and a path toward a compact and affordable gyroscope. *FY 2010 Plans:* - Initiate development of optical bench interface technology for the air-to-bandgap fiber to then be exploited for a gyroscope with reasonable bias performance levels and consistent with military needs. *FY 2011 Base Plans:* - Demonstrate full gyroscope with integrated electronics and performance exceeding 10 micro-degrees/hr drift.					
Photonic-enabled Simultaneous Transmit and Receive (P-STAR) (U) Information operation missions on multiple military platforms depend on the ability to transmit and receive radio frequency (RF) signals, simultaneously, from a single aperture. This program will develop transmit/receive modules with high transmit-to-receive isolation and low receive noise figures, over a multi-octave bandwidth, to greatly improve situational awareness of the RF environment, and enable greater control over the information domain. Additionally, the program will develop ultra-wideband (0.1 to 20 Gigahertz (GHz)) photonic components (Photodetectors & Modulators) to significantly enhanced	5.871	7.235	9.512	0.000	9.512

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
efficiency for applications in antenna Transmit/Receive (T/R) modules. Furthermore, this program will help stem the proliferation of "mission-specific" antennas by providing an ultra-wide bandwidth antenna that can substitute for multiple custom antenna solutions. It is expected that such components would have a significant impact on wideband, multi-functional, multi-beam, Active Electronically Steerable Array antennas by developing modules and detectors that are independently optimized for T/R applications. In addition to the increased functionality, the improved noise figure of the P-STAR technology will increase stand-off ranges and provide improved indications and warning. The program will transition via its industrial performers. *FY 2009 Accomplishments:* - Fabricated and demonstrated a STAR module which exhibits high T/R isolation over a multi-octave frequency range. - Initiated development of transmit optimized electro-optical transducers and photoreceivers, nominally operating in the 1550 nm band, for operation in the 0.1 to 20 GHz frequency range. *FY 2010 Plans:* - Develop and demonstrate low loss lithium niobate optical modulators, which exhibit low switching voltages and incorporate a long effective length for achieving high T/R isolation. - Develop and demonstrate a power amplifier that when connected to the electro-optic modulator and incorporated into the T/R module package, enables the transmit power goal over a multi-octave frequency range. - Enhance third-order intercept point (OIP3) of the Transmit link to +65 decibels (dB) relative to a milliwatt of power (dBm). - Enhance gain of the Receive link to 35 dB. *FY 2011 Base Plans:* - Enhance output power of the Transmit link to 15 Watts. - Enhance Noise Figure of the Receive link to 3 dB and OIP3 to +43 dBm.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Gratings of Regular Arrays and Trim Exposures (GRATE)	2.585	12.000	13.490	0.000	13.490

(U) The Gratings of Regular Arrays and Trim Exposures (GRATE) program will develop revolutionary circuit design methodologies combined with hybrid lithography tools to enable cost-effective low volume nanofabrication for DoD applications. Moore's law has driven the silicon industry for several decades with the minimum feature size on an integrated circuit (IC) reduced to 45 nm for today's commercial products. Due to challenging patterning requirements and complex circuit designs, costs of lithography tools and masks have become unaffordable for low-volume manufacture, i.e., military electronics or application specific integrated circuit (ASICs). Similarly, the circuit design, verification, and testing costs have also grown exponentially further preventing military electronics from using advanced silicon technology nodes. Military electronics capabilities are currently limited by the high cost of nanofabrication. To solve this important problem, DARPA has invested in a variety of maskless patterning technologies including parallel e-beam arrays, parallel scanning probe arrays, and an innovative e-beam lithography tool. This program will develop revolutionary circuit design methodologies coupled with innovative hybrid maskless patterning tools to realize cost-effective nanofabrication for low-volume defense or commercial ASICs. Such an approach can also address the nanofabrication requirements of other low-volume DoD technologies such as photonics and micro-electro-mechanical systems. This program will transition via industry.

FY 2009 Accomplishments:
- Developed 1-D designs and patterning methods.
- Evaluated the efficacy of regular geometry templates for improving lithographic performance for more robust imaging, simplified design/layout process, and increased throughput for maskless lithography methods.
- Verified efficacy of 1-D design approach. Quantitative benefits of 1-D vs traditional 2-D design approach. 2-D to 1-D conversion of legacy design information processing.
- Developed 1-D design enabling process extensions such as "trim/stitch" and "frequency doubling". 1-D test cell fabrication.
- Studied feasibility of custom grating fabrication tool based on interference lithography.

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop 1-D fabrication demonstrations. - Develop 1-D standard cell library for digital designs at < 32 nm node. 1-D computer aided design tool development. - 1-D fabrication demos including various circuit elements making use of 1-D specific process extensions. - Demonstrate 1-D circuit patterns using trimmed interference lithography. *FY 2011 Base Plans:* - Demonstrate grating-based design and fabrication, including experimental verification of desired patterns. The demonstration vehicles will be logic/memory "standard cells" and high speed RF devices in state-of-the-art CMOS technologies. - Develop re-usable grating and trim masks, design methodology, process design kits, and software for layout conversion from standard (2D) to grating-based (ID) layout styles. - Demonstrate wafer-scale patterning of gratings, and the customization of these gratings by the "trim/stitch" processes.					
Electromagnetic Pulse Tolerant Microwave Receiver Front End (EMPIRe) (U) The Electromagnetic Pulse Tolerant Microwave Receiver Front End (EMPIRe) program will create a wide bandwidth, tunable RF front end technology that is immune to electromagnetic pulse (EMP) attack. This program will seek an entirely new approach to RF front-end technology where all metal and front-end electronic circuitry are eliminated. Of particular interest will be an all-dielectric, electronics-free RF front end with sensitivity and dynamic range consistent with today's wireless communication and radar systems. A secondary goal is to effect a significant reduction in detectable radar cross section by eliminating the metallic antenna.	5.879	3.070	2.926	0.000	2.926

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) EMPIRe represents the ultimate solution for protecting wireless communication and radar systems. EMPIRe can find immediate application protecting tactical communication and radar systems, which are highly vulnerable to EMP attack due to their close proximity to enemy assets. As the efficiency and tunability of the all-dielectric non-electronics front-ends improve, the technology can become an ubiquitous RF front-end for all military as well as commercial wireless devices, providing the communications infrastructure immunity against EMP attacks. This program will transition through industry performers involved with reducing the susceptibility of electronics to damage from high EMP weapons. *FY 2009 Accomplishments:* - Demonstrated dramatic reduction in RF front-end susceptibility to electromagnetic pulses while maintaining militarily useful system. *FY 2010 Plans:* - Design and simulate microwave receiver front-end and model high power microwave exposure; predict robustness limits based on microwave power handling capability. - Fabricate front-end and test RF performance. - Experimentally validate power handling capability. *FY 2011 Base Plans:* - Increase microwave concentration factor and optimize components for RF performance while maintaining resiliency towards high power microwaves. - Perform experimental validation of design improvements.					
Maskless Direct-Write Nanolithography for Defense Applications (U) The Maskless Direct-Write Nanolithography for Defense Applications program will develop a maskless, direct-write lithography tool that will address both the DoD's need for affordable, high performance, low volume Integrated Circuits (ICs) and the commercial market's need for	15.000	23.035	32.560	0.000	32.560

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
highly customized, application-specific ICs. In addition, this program will provide a cost effective manufacturing technology for low volume nanoelectromechanical systems (NEMS) and nanophotonics initiatives within the DoD. Transition will be achieved by maskless lithography tools, installed in the Trusted Foundry and in commercial foundries, which will enable incorporation of state-of-the-art semiconductor devices in new military systems, and allow for the cost-effective upgrade of legacy military systems. *FY 2009 Accomplishments:* - Demonstrated rotary stage at 10 meters per second. - Demonstrated static imaging on prototype Reflective E-Beam Lithograph (REBL) system. - Demonstrated dynamic imaging on prototype REBL system. *FY 2010 Plans:* - Demonstrate System Level Lithography Performance on a Linear Stage Demonstrator System. - Design, build, and test a rotary stage. - Integrate electron beam column and rotary stage demonstrator platform. - Design, build, and characterize an enhanced electron beam column for system alpha prototype experiments. *FY 2011 Base Plans:* - Design, build, and test an electronic mask device and exercise the data path for design information. - Design and build the next generation Rotary Stage Product Platform Prototype. - Develop and demonstrate a sensitive photoresist with acceptable performance for the 32 nanometer technology requirements.					
Deep Ultraviolet Avalanche Photodetectors (DUVAP) (U) This program demonstrated avalanche photodiodes (APDs) operating in the Geiger mode, i.e. capable of counting single photons with high gain. The APDs operate in the ultraviolet, in the band	1.139	0.000	0.000	0.000	0.000

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APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	**PROJECT** MT-15: *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
centered at 280 nanometers (nm), and are designed to be insensitive to the solar flux. The two classes of materials pursued were Silicon Carbide (SiC) and Aluminum Gallium Nitride (AlGaN). The U.S. military has a need for compact, reliable, and cost-effective Geiger-mode photodetectors. Avalanche photodetectors offer high gain, low dark count, high reliability and robustness, and small form factor needed in future military applications. Technology will transition via industry. *FY 2009 Accomplishments:* - Demonstrated integrated solar-blind ultraviolet filter with appropriate cut-off. - Optimized materials for low defect density and reproducible device yield.					
Electronic & Photonic Integrated Circuits on Silicon (EPIC) (U) The Electronic & Photonic Integrated Circuits on Silicon (EPIC) program developed two critical alternative photonic technologies based on silicon substrates. The first thrust addressed active photonic components based on silicon, which do not rely on generating light within the material. While passive photonic components, such as waveguides, can be fabricated from silicon, silicon's indirect bandgap does not lend itself to fabricating active photonic components based on the generation of photons (lasers, amplifiers etc.). The EPIC program is transitioning via industry to optical communication and electronic warfare programs of interest to all Services. *FY 2009 Accomplishments:* - Demonstrated a functional Application Specific-EPIC using complementary metal-oxide semiconductor (CMOS) compatible processing.	2.125	0.000	0.000	0.000	0.000
Ultradense Nanophotonic Intrachip Communication (UNIC) (U) The Ultradense Nanophotonic Intrachip Communication (UNIC) program worked to demonstrate nanophotonic technology for access to on-chip ultra-dense systems and Input/Output (I/O) to/from a chip containing such ultra-dense systems. This technology will transition to industry.	11.000	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Demonstrated extremely low power CMOS-compatible silicon photonic devices that demonstrate a path to on-chip optical communication links that are superior to conventional electronic messaging in single-die multiprocessor computing architectures. - Integrated arrays comprised of 4-wavelength silicon photonic transmitters and 10 gigabytes/second (Gbps) receiver.					
Analog Spectral Processors (ASP) (U) The Analog Spectral Processors (ASP) program leveraged existing MEMS capabilities to make precision RF components, and perform low-insertion-loss/heterogeneous components integration to demonstrate integrated Analog Spectral Processors that greatly reduce dynamic range and bandwidth required on analog/digital converters and other front-end components. This enabled proliferation of advanced RF capabilities to the individual war fighter by dramatic reduction in size, weight, and power of RF systems. Industrial firms that are currently the major suppliers of radio equipment for defense and homeland security applications will serve as the primary transition partners upon successful completion of the program. *FY 2009 Accomplishments:* - Integrated filter banks with active components. - Conducted analysis of proposed front-end architecture. - Delivered breadboard-level filter banks to a third-party testing facility.	9.446	0.000	0.000	0.000	0.000
Microsensors for Imaging (MISI) (U) The Microsensors for Imaging (MISI) program established technology for extremely small, lightweight cameras sensitive in the short wave infrared spectrum for a wide range of applications. MISI initially focused on two important areas, micro-air vehicles and a head-mounted system. The camera components comprise a micro-system including optics, focal plane array and electronics	4.917	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
with display, energy source and illuminator included as the head-mounted system. The limitation of weight and power places demands on the sensor technology for exceptional image quality in a micro-package. This technology will have many DoD applications. This program will transition through industry performers into DoD systems, allowing integration into small robotic platforms and micro-air vehicles. *FY 2009 Accomplishments:* - Demonstrated megapixel arrays in micropackage that amplify low level optical signals with minimum excess noise while maintaining uniformity across the array. - Demonstrated operation at room temperature over military temperature range.					
Visual Processors Embedded for Real-Time Exploitation (VERTEX)* *Formerly titled Space, Time Adaptive Processing (STAP) BOY. (U) The Visual Processors Embedded for Real-Time Exploitation (VERTEX) program researched miniature, low-power, low-cost, teraflop-level signal processing solutions derived from commercial Graphics Processor Unit (GPU) hardware and software of the type currently used for fast geometry computations in hand-held electronic games like Nintendo's GAME BOY (Registered Trademark). The VERTEX technology will transition to the Army. *FY 2009 Accomplishments:* - Developed and tested military application prototypes utilizing VERTEX technology.	2.824	0.000	0.000	0.000	0.000
High Operating Temperature - Mid-Wave Infrared (HOT MWIR) (U) The High Operating Temperature - Mid-Wave Infrared (HOT MWIR) program worked to establish technology for high-speed sampling and high-spatial resolution infrared focal plane arrays that operate in the mid-wave infrared without cryogenic cooling. The high sampling speed is required for both threat	8.374	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
detection and for imaging from fast moving platforms. The program technology will transition via industry for applications such as multi-band mid-wave or micro-detectors. *FY 2009 Accomplishments:* - Demonstrated thermal array with novel pixel structure showing low thermal mass and reduction in low frequency noise. - Demonstrated mid-wave photon detector array with dark current reduced to be comparable to the current from background radiation.					
Disruptive Manufacturing Technologies (DMT) (U) The Disruptive Manufacturing Technologies (DMT) program worked to achieve significant and pervasive cost savings, and/or decreases in cycle time, for existing or planned procurements. There has been a long-standing desire to replace traveling wave tube amplifiers (TWTAs), which are pervasive in nearly all electronic warfare (EW), information warfare (IW), radar, and communication systems with lower cost solid-state components. It will be replaced with solid-state hybrid microwave integrate circuit (HyMIC) modules developed by merging Polystrata and GaN technologies. The result will be a 10x reduction in TWTA cost for the Integrated Defensive Electronic Countermeasures (IDECM) program, a joint Navy-Air Force program. The program will transition into the joint Navy-Air Force IDECM program. *FY 2009 Accomplishments:* - Demonstrated a form-fit-function 160 W GaN amplifier ready for insertion into the IDECM decoy module.	2.392	0.000	0.000	0.000	0.000
Adverse Weather Landing System (U) The Adverse Weather Landing System program worked to provide the military pilot with an enhanced visual situational awareness capability to assist in making landing approaches in adverse	2.275	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
weather and low visibility conditions. The ability to eliminate poor visibility due to rain, fog, sand storms, and snow storms using electro-optical and signal processing techniques could save lives and loss of aviation equipment. This program will transition via industry. *FY 2009 Accomplishments:* - Conducted feasibility study incorporating the results from the static runway measurements, outside data collection sources, and dynamic flight tests. - Developed requirements to support the development of a high resolution sensor pertinent to limited visibility flight operations.					
Data in Optical Domain Network (DoD-Network) (U) Currently, optical networks use photonics to transport data and electronics to process data. However, as the underlying bit rates of the optical networks are pushed beyond 40 giga-bits per second there will be significant processing bottlenecks in these networks and these bottlenecks will severely limit the military's ability to rapidly transport time critical information. A potential solution to this problem is to develop photonic technology so optics can take over higher order network processing functions. The Data in Optical Domain Network (DoD-Network) program explored four key photonic technologies to meet these challenges: all-optical routing, all-optical data buffering (controllable and eventually random access), optical logic and circuits, and all-optical (multi-wavelength) regenerators. These photonic technologies will lead to intelligent all-optical networks. The program had two major areas of interest: the first focused on developing new photonic technology that is essential if photonics is to play a significant role in higher order processing in optical networks, the second area focused on developing novel architectures that will fully exploit the new photonic technology to bring new and increased functionalities to the optical networks. The DoD-Network program will transition via industry to high-speed, high-capacity optical networking programs of interest to the Air Force. *FY 2009 Accomplishments:* - Developed an all-optical data router (ODR) with high data rate ports.	3.744	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Precision Navigation	0.000	0.000	7.342	0.000	7.342
(U) The Precision Navigation program goal is to provide compact, rugged, low-power and extremely accurate means for determining position. The resulting systems will provide accurate tools for GPS-denied vehicle operation, on-foot cave and building exploration, precision munitions delivery and many other applications where previous options were too heavy, inaccurate, large or power-hungry. In order to achieve this, sensors will be developed to use internal and external reference information to maximum advantage. One component of the internal type is the development of a new class of microsystems capable of measuring the absolute angle of rotation with the ultra high precision, effectively operating as a mechanical integrator of rotation (MIR). The MIR will not rely on any absolute reference, but will define the reference itself in the absolute inertial space. The device will measure angle of rotation at an unprecedented precision of arc-seconds and a bandwidth in tens of kHz (all characteristics are at least 3 orders of magnitude better than the state-of-the-art). Another component of the program is the development of navigation grade integrated micro gyroscopes with the goal of achieving 0.01 deg/hr bias drift in very compact form factors (less than 1 cm3) and a total power consumption less than 5 mW per sense axis. Another key goal of this program is to harness external references where possible, which can be fused with internally referenced navigation signals to greatly improve performance. One approach to be pursued is the development of miniaturized atomic gradiometer arrays (AGA). Reducing previously bulky and high power AGA's to micro-scales will entail the use of nuclear magnetic resonance phenomena in extremely compact packages for timekeeping, rotation and magnetic field measurements. The AGA's will be deployed in arrays on the order of 10,000 individual sensors, each with the unprecedented target sensitivity of 0.1 femtoTesla (fT). This level of performance will yield not only highly capable navigation instruments making use of local gravitational variations, but also portable devices that are able to detect unexploded bombs/IEDs, camouflaged/faked military assets from platforms such as UAV's. When combined in systems, these new technologies will yield unprecedented navigational capabilities and help deny any advantage for adversaries who might interfere with GPS availability. Technology is expected to transition through industry.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Define miniaturization trade-offs with gyroscope performance to package and ruggedize. - Investigate in-ear plug design that protects ears from damaging sound levels while preserving hearing and sound localization. - Define functional requirements for key micro and nanotechnologies for the sequencer. - Demonstrate surface-enhanced Raman scattering using nanoplasmonic structures. - Demonstrate integration path for light sources and spherical atomic shells in arrays on a single wafer.					
Accomplishments/Planned Programs Subtotals	115.447	109.131	132.602	0.000	132.602

	FY 2009	FY 2010
Congressional Add: Center for Autonomous Solar Power *FY 2009 Accomplishments:* - Initiated solar power development.	4.000	0.000
Congressional Add: Hybrid Power Generation System *FY 2009 Accomplishments:* - Explored hybrid power technologies including new high-density power generators based on breakthrough configurations of permanent magnet materials, coil designs, and advanced power electronics.	1.200	0.000
Congressional Add: Ultra Low Power Electronics for Special Purpose Computers/Ubiquitous Computing	1.600	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
FY 2009 Accomplishments: - Continued low power nano scale electronics development.		
Congressional Adds Subtotals	6.800	0.000

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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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	297.643	269.198	219.809	0.000	219.809	202.240	221.808	241.455	247.523	Continuing	Continuing
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	40.870	89.702	69.450	0.000	69.450	69.510	58.418	45.555	45.510	Continuing	Continuing
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	163.681	91.301	64.376	0.000	64.376	64.155	63.412	63.442	64.730	Continuing	Continuing
CCC-CLS: *CLASSIFIED*	93.092	88.195	85.983	0.000	85.983	68.575	99.978	132.458	137.283	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Command, Control and Communications Systems program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The goals of the Command and Control Information Systems project are to develop and test innovative, secure architectures and tools to enhance information processing, dissemination and presentation capabilities for the commander. This will give the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making and execution support capability and provide secure multimedia information interfaces and assured software to “on the move” users. Integration of collection management, planning and battlefield awareness programs is an essential element for achieving battlefield dominance through assured information systems.

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. The principal element of this project is assured communications using standard and non-traditional means, on and off the battlefield.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	328.073	293.476	0.000	0.000	0.000
Current President's Budget	297.643	269.198	219.809	0.000	219.809
Total Adjustments	-30.430	-24.278	219.809	0.000	219.809
• Congressional General Reductions		-1.128			
• Congressional Directed Reductions		-23.150			
• Congressional Rescissions	-14.511	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-6.702	0.000			
• SBIR/STTR Transfer	-9.217	0.000			
• TotalOtherAdjustments	0.000	0.000	219.809	0.000	219.809

Change Summary Explanation

FY 2009

Decrease reflects Omnibus Reprogramming action for the H1N1 vaccine development, Section 8042 rescission of the FY 2010 Appropriations Act, SBIR/STTR transfer and internal below threshold reprogramming.

FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts.

FY 2011

Not Applicable

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	40.870	89.702	69.450	0.000	69.450	69.510	58.418	45.555	45.510	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) Military operations since the end of the Cold War illustrate that current theater-level command, control, communications, and intelligence/information systems lack the ability to fully support operations in complex, time-critical environments. Warfighters must be prepared for operations ranging from conflict and peacekeeping in urban centers to heavy battle actions in remote areas. Current capabilities do not provide the commander with real-time, secure, situational awareness or the ability to orchestrate high-tempo planning, rehearsal, and execution. The programs in this project are developing and testing innovative, secure architectures and tools to enhance information processing, dissemination, and presentation capabilities. The programs provide the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making, and execution, secure multimedia information interfaces, and software assurance to the warfighter "on the move." Integration of collection management, planning, and battlefield awareness are essential elements for achieving battlefield dominance through assured information systems.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Heterogeneous Airborne Reconnaissance Team (HART)	4.000	7.901	6.000	0.000	6.000
(U) The Heterogeneous Airborne Reconnaissance Team (HART) program develops integrated tactical planning and sensor management systems for heterogeneous collections of manned and unmanned platforms operating in urban environments. HART employs a model-based control architecture with dynamic teaming and platform-independent command and control. The system registers new platforms with the battle manager (kinematics, maneuverability, endurance, payloads, and communications links) to facilitate platform-independent tasking. HART provides a commander's interface that allows collaborative tasking of the platforms in the form of operational missions, such as search, track, identify, or engage, rather than routes and events. Additionally, it supplies computationally intensive decision aids, such as advanced 4-D airspace and groundspace deconfliction tools, route planners, and task/ platform assignment algorithms. The technology presents mission status and future courses of action					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
to commanders for collaborative adjudication. HART enables augmentation of low-footprint, rapidly deployable, easily sustainable human command structures with teams of machines operating together. There is a Memorandum of Agreement in place with the U.S. Army for technology transition. *FY 2009 Accomplishments:* - Supported user training operations at Ft. Bliss/Ft. Hood. - Conducted training and field testing with the Army Evaluation Task Force (AETF) to identify capabilities ready for rapid transition. - Extended operational area of small unmanned aerial vehicle (SUAV) via planning and control for "fling forward." - Added moving target indicator (MTI) for target tracking. - Provided dynamic overwatch to mobile warfighters by adapting flight paths, sensor and communications footprints, and by planning for UAV handoffs. - Demonstrated HART interoperability with service airspace management and imagery dissemination systems. - Expanded HART capability to rotorcraft (FireScout). *FY 2010 Plans:* - Test and demonstrate cooperative interaction with Tactical Airspace Integration System (TAIS) to achieve permissive airspace management for manned and unmanned platforms and indirect fires. - Support operational evaluation and certification of capabilities and limitations. - Collaborate with Program Manager, Unmanned Aircraft Systems and Army G-2 Intelligence, Surveillance, Reconnaissance Task Force lead to integrate and transition selected capabilities to the U.S. Army. - Ruggedize and miniaturize hardware suite. - Ensure scalability appropriate to anticipated areas of employment. - Support operational transition of technology in Program Execution Office Aviation Programs of Record.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Formulate and assess geo-registration algorithms suitable for highly variable terrain. - Develop new collection management methods that account for terrain-induced routing constraints, ground field of view mapping, and sensor visibility constraints.					
Deep Green (U) Deep Green is a next-generation, battle command and decision support technology that interleaves anticipatory planning with adaptive execution to help the commander think ahead, identify when a plan is going awry, and prepare options before they are needed. Deep Green will radically reduce the time needed to plan and execute military operations and will reduce the number of staff officers needed in an operations center. Through rapid mission planning and execution and reduced staff overhead, Deep Green will save lives and reduce costs. Deep Green will automatically induce a plan and commander's intent from the commander's hand-drawn sketches with accompanying speech to facilitate rapid option creation. Deep Green generates a broad set of possible futures from those options for all sides in an operation and predicts the likelihood of each future. It supports anticipatory planning by using information about the ongoing operation to nominate future states that are no longer feasible and probable future states upon which the commander should focus additional planning efforts. By anticipating decision points early and allowing the commander to explore the future option space, Deep Green supports commander's visualization and adaptive execution, enabling correct, timely decisions by the commander. Deep Green technology will transition to the U.S. Army. *FY 2009 Accomplishments:* - Developed sketching and speech tools to help commanders generate options quickly. - Developed fast, multi-resolution models to generate possible futures. - Developed the ability to automatically evaluate diverse possible futures. - Developed interface allowing commanders to foresee downstream effects of decisions.	10.949	19.282	17.727	0.000	17.727

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Extend technologies to monitor an ongoing operation and update the likelihoods that the possible futures being generated by Deep Green will actually occur. - Integrate major components to produce an initial prototype Deep Green system that enables proactive (vice reactive) battle management. - Extend the Deep Green system to support both mid-intensity conflict and counter-insurgency operations. - Extend the Deep Green system to support additional battlefield functional areas, such as air defense, intelligence, and military engineering. - Begin the process of transitioning Deep Green technologies to fielded battle command systems. *FY 2011 Base Plans:* - Extend Deep Green to support multi-echelon operations, including Deep Green systems at brigade and battalion levels coordinating among themselves. - Demonstrate functional battle command technology in force-on-force exercises against a live, intelligent enemy. - Demonstrate fully-functional, multi-echelon, full-spectrum battle command technology. - Complete transition of the technology to fielded battle command systems.					
Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis) (U) The Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis) program will develop an integrated, soldier-worn situational awareness system that allows the small unit leader to generate iconic representations of hand/arm signals and transmit the iconic commands to a networked squad. The icons are geo-registered on the battlefield and viewed from each warfighter's perspective using a see-through, head-mounted display. The system will enable the small unit leader to conduct non-line-of-sight combat operations using hands-free, iconic command and control while on the move. Information management protocols will support the dissemination of tactical information to allow the	10.000	11.050	8.823	0.000	8.823

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
squad leader to hand-off actionable information and direct alerts to the squad/fire teams for real-time collaboration without overload. ULTRA-Vis will develop the key technologies that allow small unit leaders and members to selectively transmit critical combat information in the form of icons using existing, low-bandwidth soldier voice and data radios to covertly relay standard phrases and visual annotations. ULTRA-Vis empowers the small unit leader with a clear tactical advantage through inter/ intra-squad collaboration, heightened situational awareness and the ability to take decisive action while on-the-move. The ULTRA-Vis prototype units are planned for transition to the U.S. Army, Air Force Special Operations Command (AFSOC), and U.S. Marine Corps at the completion of the program. *FY 2009 Accomplishments:* - Developed see-thru display conformal visor using holographic waveguides and substrate guided relays. - Developed optically-assisted navigation for continuous geo-location and pose estimation. - Developed interface to actuate non-verbal commands and post icons onto a shared urban landscape. *FY 2010 Plans:* - Develop the capability to recognize standard hand and arm signals used by small unit leaders in close range combat operations. - Develop the capability to create geo-registered icons and affix the icons with high placement accuracy to the shared urban landscape for display from each warfighter's perspective. - Develop a non-occluding, head-mounted see-through visor for viewing iconic overlay on the battlespace. *FY 2011 Base Plans:* - Create network protocols for alerts and information management for inter-squad collaboration. - Integrate a multi-mode testbed to evaluate system functionality and capabilities.					
Advanced Tactical Battle Manager	3.000	10.800	7.900	0.000	7.900

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Advanced Tactical Battle Manager program develops automated decision support tools for Army and Marine Corps tactical commanders at the division level and below. The program provides support for combined operations employing dismounted soldiers, manned platforms, and autonomous vehicles through a graphical interface with unit commanders. The program also extends plans by applying adversarial reasoning techniques to identify vulnerabilities and opportunities in the predicted enemy course of action. Finally, it examines modifications or counteractions to reduce vulnerabilities. Program products will transition to the Services. (U) The effort is developing a support tool that autonomously and continuously, during the execution of a military operation, tracks the state of what is known about the environment and provides automated assistance to the process of collections planning to enable more effective, rapid, complete identification of the enemy's state. (U) The program will also develop integrated, in-theater tools for organizational design, cognitive resource configuration, and adaptive management of complex, often unconventional command and control (C2) structures. These tools will enable the U.S. military in real time to modify responsibilities, relations, tasks, and priorities to meet the rapidly changing needs of the command across multiple units, echelons, and organizations, while shaping the choices of countries at strategic crossroads. U.S. forces increasingly encounter complex C2 structures that include Coalition forces (manned and unmanned), civilian agency resources, indigenous formal and informal powers, and non-governmental organizations, and the U.S. Army Training and Doctrine Command has identified a critical gap in the technologies for agile configuration and analysis of C2 structures. *FY 2009 Accomplishments:* - Created algorithmic approaches for converting commander's and staff's information needs into tangible surveillance requests.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Develop and evaluate via simulation system solutions. - Conduct laboratory tests and obtain user feedback. - Provide predictive and diagnostic estimation of C2 system health and status in terms of the ability of those systems to support operational missions. - Proactively prosecute anomalies in context operational mission priorities. *FY 2011 Base Plans:* - Automatically determine the impact of multiple correlated anomalies on operational activities. - Develop dynamic approaches to allocating critical C2 functions, relations, and information flows over space and time. - Adapt C2 plan to support mission needs. - Develop active visualizations to support C2 system situation awareness and understanding.					
Increased Command and Control Effectiveness (ICE) (U) The Increased Command and Control Effectiveness (ICE) program develops and integrates cognitive systems technology into operational Command, Control, and Intelligence (C2I) systems. DARPA's Cognitive Systems programs have been developing the machine learning, reasoning, and human-machine dialogue technologies necessary to create cognitive assistants. This new technology promises to enable information systems to adapt automatically, during deployment and in real time, to the changing conditions that military commanders confront. It enables commanders to more rapidly adapt to evolving situations and priorities, and accelerates the incorporation of new personnel into command operations. This program funds portions of the technologies developed in PE 0602304E, Project COG-02 that are ready for application to command and control and situational awareness systems.	6.005	10.909	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) Efforts to integrate cognitive technology into a number of operational systems are underway. The very positive initial results obtained with these important command and control systems suggest that nearly all command and control systems can benefit from an infusion of cognitive technology if the software integration effort itself is made simple. A cognitive software framework will provide basic applications that can be customized by an application developer in a relatively straightforward fashion. *FY 2009 Accomplishments:* - Developed and refined advanced operational prototypes of cognitively-enhanced versions of operational systems that would provide users with advanced information and task-management capabilities, such as learning to anticipate users' information needs, pre-fetching needed information, learning users' interests, alerting users about the occurrence of events of interest, managing message traffic, and learning routine procedures and when to execute them. - Demonstrated, tested, and evaluated Personalized Assistant that Learns (PAL) program-enhanced information systems in military settings to validate that the PAL technologies are robust to the dynamics and uncertainties of the battlefield and dramatically compensate for end-user "cognitive overload." - Hardened and refined the PAL Learning Services Framework. *FY 2010 Plans:* - Extend PAL analyst support capabilities based on test and evaluation in exercises along with end-user feedback. - Integrate PAL-based prototypes with operational C2I information systems and data sources at end user facilities as integral subsystems. - Deploy a hardened capability for evaluation in an Army military readiness exercise. - Evolve and improve the PAL Learning Services Framework based on developer feedback and release for general use.					
ZETA	0.000	29.760	29.000	0.000	29.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The ZETA program is exploring the unclassified aspects of novel physical devices, concepts, and techniques that leverage quantum physics for information technology. Research in this area has the ultimate goal of demonstrating information technology components with radical improvements in power efficiency and/or computational power relevant to military applications and opportunities. *FY 2010 Plans:* - Continue validation of key physical device assumptions. *FY 2011 Base Plans:* - Continue validation of key physical device assumptions. - Initial planning for small-scale demonstration of key physical devices.					
Predictive Analysis for Naval Deployment Activities (PANDA) (U) Predictive Analysis for Naval Deployment Activities (PANDA) developed technologies to automatically learn normal activity models of motion and emission for maritime surface vessels, automatically detect anomalous behavior, provide context modeling to resolve known categories of anomalies (e.g., due to weather and business rule changes), and generate alerts. The resulting technologies can be extended and applied to a wide range of applications including ground vehicles, troop movements, and individual targets of interest as the methods of tracking those targets improves. There is a Memorandum of Agreement in place with the Director of Naval Intelligence for technology transition. *FY 2009 Accomplishments:* - Enhanced initial system capability at operational naval site. - Commenced final phase III development in collaboration with the naval customer. - Obtained collaborative Navy funding to execute Phase III development in conjunction with DARPA funding.	6.000	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Urban Commander	0.916	0.000	0.000	0.000	0.000
(U) The Urban Commander program developed automated tools to help ground commanders construct detailed, realistic operational plans, particularly in nontraditional and urban environments. The primary effort in this thrust, the Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS), developed, integrated, and demonstrated an advanced night vision visualization system. Prototype systems have been built. The system consists of a multispectral sensor suite with a high-resolution display and a high performance vision processor, along with a power supply and radio. The prototypes provide the soldier with digitally fused, multispectral video imagery in real-time from the Visible/Near Infrared (VNIR), the Short Wave Infrared (SWIR) and the Long Wave Infrared (LWIR) sensors via the high-resolution display. The processor adaptively fuses the digital imagery from the multispectral sensors providing the highest context, best nighttime imagery in real-time under varying battlefield conditions. There is a Memorandum of Agreement in place with the Program Executive Office-Soldier and Night Vision and Electronics Sensor Directorate for transition at the conclusion of Phase III in the first quarter of FY 2010. *FY 2009 Accomplishments:* - Completed test and integration of the MANTIS vision processor. - Fabricated and tested prototypes. - Transitioned MANTIS prototypes to the U.S. Army (PEO Soldier).					
Accomplishments/Planned Programs Subtotals	40.870	89.702	69.450	0.000	69.450

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

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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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	163.681	91.301	64.376	0.000	64.376	64.155	63.412	63.442	64.730	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. Through the use of wideband dissemination and integrated sensor management, the project will also facilitate multi-site, real-time, collaborative situation assessment and course-of-action evaluations to enable true network centric warfare concepts.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Optical & RF Combined Link Experiment (ORCLE) (U) The Optical & RF Combined Link Experiment (ORCLE) program seeks to develop combined radio frequency (RF) and free space optical (FSO) communications as well as networking technologies that exploit the benefits of complementary path diversity. This effort encompasses the extension of research into the FSO/RF Internet Protocol-based Gateway Network system for tactical reach-back applications called the Optical RF Communications Adjunct (ORCA). Using optical and RF communication techniques, ORCLE will demonstrate improved battlespace communications using a hybrid RF and FSO link in air-to-air-to-ground environments. The central challenge is to enable optical communications bandwidth without giving up RF reliability regardless of the weather. ORCLE will develop RF and FSO propagation channel analysis, coding techniques and modeling to include weather, atmospherics and aero-optics to provide the joint force commander assured high-data rate communications. The technical objective is to prototype and flight demonstrate hybrid FSO/RF air-to-air-to-ground links that combine the best attributes of both technologies and simulate hybrid network performance. The ORCLE technology is planned for transition to the Special Operations Forces and the Air Force in FY 2011.	60.765	31.496	19.070	0.000	19.070

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Constructed and field tested a brassboard system incorporating the FSO/RF components and dynamic network communication and interface system. - Performed range and flight demonstrations of hybrid FSO/RF links in operational representative environment. - Integrated and tested the ORCLE terminals to verify performance and readiness for field experiments and demonstrations. - Developed, designed, and initiated building hardware and software of a prototype system for integration into military air and ground platforms. - Began coordinating field demonstrations of ORCA networking that supports multiple airborne platforms, a ground node with direct interface to the Global Information Grid, and a ground node with an interface to a tactical gateway supporting Internet Protocol (IP)-addressable nodes. *FY 2010 Plans:* - Demonstrate high availability, gigabit data flow network performance with air-to-ground nodes. - Execute a Critical Design Review that provides the information to build prototype system including FSO, RF, network, and related components for airborne to airborne to ground network use. - Perform a series of flight experiments and gather performance metrics and performance utilizing locations in the eastern and western U.S. - Complete design and build multiple ORCA nodes to be contained in aircraft wing pods for airborne hybrid FSO/RF and network link validation experiments and demonstrations. - Complete system upgrade of Optical Automatic Gain Control and Optical Modem. - Integrate improved adaptive optics, e.g., lighter deformable mirror, and faster steering mirrors, into an airborne optical link system that will be incorporated into the ORCA prototype to provide gigabits of data over long ranges with high reliability and quality. - Complete design and build of a router for integration into ORCA prototype. - Validate adaptive optics approaches and control methods during ground checkout and air-ground testing.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Develop and execute a test program to validate program design metrics, network performance, and high data rate reliability. - Validate the ability to provide the warfighter low latency information for command and control as well as ISR requirements. - Demonstrate network instantiation and user interfaces to command and control at multiple levels. - Complete ORCA prototype nodes and install on a minimum of three aircraft networked to ground terminals for global information grid interoperability and worldwide data distribution as well as battlefield command and control. - Design and execute a test plan to show ability to provide reliable high data rate information based on military needs and mission requirements are available for immediate decision making. - Demonstrate hybrid high data rate FSO/RF and advance network capabilities to validate the ability to operate over a large theater of operations. - Perform a series of flight experiments and gather performance metrics and demonstrate ORCA capability utilizing military ranges and locations in the eastern and western U.S. locations. - Complete transition of the technology.					
Disruption Tolerant Networking (DTN) (U) The Disruption Tolerant Networking (DTN) program is developing network protocols and interfaces to existing delivery mechanisms ("convergence layers") that provide high reliability information delivery using communications media that are not available at all times, such as low earth satellites, Unmanned Aerial Vehicle (UAV) over-flights, orbital mechanics, etc. The program is developing a single model for bundling information and ensuring its delivery, through a series of episodic communications links, from generator to user. Mechanisms and protocols that reduce bandwidth consumption, reduce latency, and improve reliability of information delivered to tactical deployments will be explored. The program is also exploring a new security model which protects information held in portable devices. To maximize the applicability and commercial viability of these protocols, and develop the basic software in an open	7.135	1.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
source mode, the military, commercial and Internet communities have been engaged. These protocols will be implemented in a typical military system to verify both the performance of the protocol and to validate the utility. The DTN technology is planned for transition to the USMC. *FY 2009 Accomplishments:* - Integrated DTN into USMC software interoperability environment and prepared for operational tests. - Initiated integration of DTN into USMC military tactics, techniques, and procedures. - Designed and initiated insertion into prototype DTN tactical networks. *FY 2010 Plans:* - Transition DTN to USMC.					
Retro-directive Ultra-Fast Acquisition Sensor (RUFAS) (U) The Retro-directive Ultra-Fast Acquisition Sensor (RUFAS) effort will design, construct, and demonstrate an X-band noise correlating radar with a retro-directive antenna. This effort will research and develop a new type of radar sensor based on the correlations of the Gaussian noise received by an antenna array from a small object located in the far field of the antennas and the retro-directive reradiation of the correlated noise. Combining and tailoring noise correlating interferometry and retro-directive antenna arrays into a retro-directive noise-correlating (RNC) radar will allow the radar to operate in omni-directional search mode. The result of this project will be a new type of search-mode radar having promising performance in terms of short acquisition time and low probability-of-intercept. The RUFAS technology is planned for transition to the Army and Marines. *FY 2009 Accomplishments:* - Conducted cost trade study and determined system design limitations to finalize RUFAS design capabilities. - Performed field evaluations of system design and performance at military locations. - Developed plan and executed military utility and system design assessment.	1.000	1.265	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Execute development of system design and manufacturing techniques to produce RUFAS prototype system for military utility. - Determine performer and government organizations to collaborate on experimentation and evaluation. - Perform brassboard experiments with components to determine performance. - Conduct field experiments in support of USMC end-user field evaluation.					
Network Enabled by WDM-Highly Integrated Photonics (NEW-HIP) (U) The Network Enabled by WDM-Highly Integrated Photonics (NEW-HIP) program will facilitate building or upgrading military aircraft and other aerospace platforms with a wavelength division multiplexed (WDM) single-mode fiber-optic networking infrastructure. This will have many capabilities that are well beyond those of currently used copper- and multi-mode-fiber-based technologies. Originally, the program focused on specific technologies for application on the Navy's EA-6B Prowler aircraft; however, the program has been broadened to focus on technologies that will provide advanced capabilities to a multitude of military aircraft, such as the Joint Strike Fighter (JSF). The NEW-HIP technologies and associated architecture will provide: scalability in the bandwidth and the number of connected devices; immunity to electromagnetic interference (EMI) and cable cross-talk; reduced cable and overall system weight and volume; increased reliability without an associated weight or volume penalty; ease of integration and future upgradeability; and the ability to carry mixed analog and digital signal formats. This will be accomplished by taking full advantage of single-mode fiber-optic WDM technology and leveraging optoelectronic and photonic integration techniques developed in DARPA photonics components program. To reduce the size, weight and power and to increase the reliability and the flexibility of interconnecting arbitrarily placed client devices with various signal formats, the NEW-HIP program will use passive, transparent and wavelength-routing technology at the core of the network, and tunable optical transmitters and receivers (transceivers) to inter-connect the client devices at the edge of the network. The technologies developed under this program are planned for transition	4.845	5.100	2.983	0.000	2.983

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
to the Services for eventual incorporation into military aircraft, including tactical aircraft, UAVs, wide-bodied aircraft and rotorcraft. *FY 2009 Accomplishments:* - Developed preliminary architectures of the avionics optical network that satisfies the requirements for networking analog and digital signals. - Developed the preliminary performance specification for NEW-HIP circuits to satisfy the performance and environmental requirements of military aircraft. - Designed and prototyped the following key optoelectronic components: tunable digital transmitters, tunable digital receivers, and passive wavelength broadcasting and routing components with focus on digital performance metrics. - Developed the preliminary designs for analog transmitters and receivers. *FY 2010 Plans:* - Develop the final architecture of the avionics optical network that satisfies the requirements for networking analog and digital signals. - Develop the final performance specification for NEW-HIP circuits to satisfy the performance and environmental requirements of military aircraft including the Joint Strike Fighter (JSF). - Continue the development and prototyping of the digital optoelectronic components including environmental testing. - Begin development of analog optoelectronic components. - Conduct developmental performance testing of the digital links using prototype network components. *FY 2011 Base Plans:* - Continue development of the key optoelectronic digital and analog networking components with respect to performance, size, weight, power and environmental requirements.					
Military Networking Protocol	5.793	9.000	9.750	0.000	9.750

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Military Networking Protocol program seeks to develop networks with full military organizational unit attribution and prioritization. The program will develop an authenticated and trusted version of Transmission Control Protocol/User Datagram Protocol/Internet Protocol (TCP/UDP/IP). By providing full attribution of every device and tracking each device's network flows, the system will know who owns each data flow. Based upon this knowledge, Military Networking Protocol will be able to provide a prioritization scheme of up to thirty-two levels. Military Networking Protocol will allow the network infrastructure to provide prioritization levels, reallocate bandwidth between different users or different military units, and automatically make quality of service decisions. Military Networking Protocol traffic will be compatible with existing Internet infrastructure and may allow or deny entry or transit of unauthenticated data and transmit data as fast as (or faster than) existing network protocols. Hardware developed in this program will be self-configuring and will greatly reduce the need for trained network personnel and overall network's maintenance cost. This program is planned for transition to the military Services. *FY 2009 Accomplishments:* - Developed technical scheme to allow for inserting attribution data into existing TCP/IP packets with a minimal amount of overhead. *FY 2010 Plans:* - Develop tactical router replacements that work with existing computers/routers and require no new configuration and enable self-forming networks that will result in at least an order-of-magnitude reduction in training, configuration, and installation time. - Develop changes to TCP/UDP/IP to accommodate Military Networking Protocol functionality. *FY 2011 Base Plans:* - Conduct demonstrations in operationally relevant environments.					
Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART)	5.922	10.540	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART) program is developing a new technology for producing very thin millimeterwave array apertures and transceivers. The technology development will culminate in the demonstration of a large-sized coherent, active electronically steerable array (AESA) with an output power density of 5W per square cm and a total layer thickness of less than 1cm. The SMART technology approach will result in a breakthrough in performance over conventional millimeterwave approaches. The 3-dimensional (3-D) multi-layer assembles that are being developed will greatly reduce AESA packaging complexity and will enable very compact, low-cost, millimeterwave and radio frequency circuit "building blocks" to combine to form arbitrarily large arrays. New capabilities, such as the ability to construct reconfigurable and/or multi-band AESAs and other MMW circuits, will be enabled by this architectural approach. This program will transition through industrial producers of MMW radar systems for DoD applications. *FY 2009 Accomplishments:* - Incorporated receive capability into the AESA while maintaining the thin dimension. - Demonstrated high isolation between transmit and receive functions. - Conducted evaluations and demonstrations of prototype components. - Initiated development of design automation algorithms and tools. *FY 2010 Plans:* - Complete initial testing of integrated components at high frequencies. - Demonstration of a large-size integrated transceiver array of 400 active elements with high output power, low losses, and low noise. - Complete final demonstrations of transceiver technology.					
Analog Logic* *Previously a part of Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART).	6.625	6.486	7.650	0.000	7.650

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Analog Logic program will develop and demonstrate architectures, designs, and development tools for implementing computational functions in analog circuitry to overcome performance limitations inherent in digital designs. This program will apply the technologies to signal processing functions typically performed in digital form, which experience design complexity, high power consumption, thermal loads, limits to computational speeds, loss in dynamic range, and susceptibility to manufacturing variances. The Analog Logic program will build and demonstrate an analog-only signal processing capability with no local oscillator, down conversion, or analog-to-digital conversion. The Analog Logic program will also develop the algorithm libraries and automated development tools needed for developing algorithms in a low-cost fashion similar to Very-High-Speed Integrated Circuit (VHSIC) Hardware Description Language (VHDL). (U) The Analog Logic program has the potential to reduce complexity and power requirements for signal processing functions while improving performance relative to digital implementations in field programmable gate arrays (FPGA), digital signal processors (DSP), and general purpose processors (GPP). The result is a significant reduction in system cost, increase in battery life, and higher system reliability and performance for critical wireless military communications system components. As a consequence of this effort, there will be a great saving in cost, power, and volume to many modern military systems implementing wideband signal spreading, spectrum utilization, multiple input multiple output channels and radar applications. This program is planned for transition to the Army. *FY 2009 Accomplishments:* - Demonstrated initial analog logic signal processing prototypes. - Developed integrated analog logic circuitry for insertion into prototype radio receiver. - Designed concepts and tools for integrated design flow of analog logic circuitry. *FY 2010 Plans:* - Demonstrate end-to-end capability of a receiver prototype using integrated analog logic components.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**PROJECT** CCC-02: *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop and demonstrate an initial capability for automated design and synthesis of analog logic circuitry using the Hardware Description Language (HDL). - Produce designs for ultra high-speed analog logic components. - Establish technology transition planning for use of the analog logic capability for DoD applications. *FY 2011 Base Plans:* - Develop and demonstrate an all analog logic receiver prototype with no frequency conversion or digital components. - Demonstrate the automated design and synthesis of advanced high-speed analog logic circuitry using the HDL, to include design verification capabilities. - Complete technology transition of the analog logic capability for DoD applications.					
Wireless Network after Next (WNaN) (U) The Wireless Network after Next (WNaN) program goal is to develop and demonstrate technologies and system concepts enabling densely deployed networks in which distributed and adaptive network operations compensate for limitations of the physical layer of the low-cost wireless nodes that comprise these networks. WNaN networks will manage node configurations and the topology of the network to reduce the demands on the physical and link layers of the nodes. The technology created by the WNaN network effort will provide reliable and highly available battlefield communications at low system cost. (U) The WNaN program will develop a low-cost handheld/body wearable wireless node that can be used to form high-density ad-hoc networks and gateways to the Global Information Grid. This program will also develop robust networking architecture(s) and network technologies/processes that will exploit high-density node configurations. A MOA is in place between DARPA and the Army that will culminate in a large-scale network demonstration using the multichannel nodes to establish viability for the Army to transition to a program of record and procure WNaN devices. Transition of the WNaN technology to the Army is planned to begin in 2010 and complete in 2011.	32.295	14.414	6.923	0.000	6.923

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Conducted a demonstration of six prototype WNaN radios with low risk networking technology to include Combat Net Radio through packetized voice, transmitting/receiving situational awareness data, IP layer services through Ethernet connection, interoperable with legacy tactical radios and Position Location Information (PLI). - Initiated development, integration, test and simulation of the additional network technologies that exploit diverse paths and frequencies to support network scalability and network formation of tens of thousands of operational nodes. - Initiated development of advanced prototype WNaN radios in a producible form factor for the Army to conduct field experimentation in support of a decision to transition the WNaN technology. - Began working with the Army to develop a network simulation model that can show ad-hoc wireless network performance for >1000 nodes. *FY 2010 Plans:* - Conduct field demonstrations of prototype WNaN radios with enhanced networking technology to include Disruption Tolerant Networking (DTN) and Dynamic Spectrum Access (DSA) capability with spectrum policy reasoning engine. - Simulate WNaN mobile ad-hoc wireless network performance for networks of >1000 WNaN nodes. - Demonstrate a communication system where the network layers can mitigate shortfalls in the radio physical layer. - In conjunction with the Army, conduct experimentation of advanced prototype WNaN radios with enhanced network technologies that improve mobile ad-hoc wireless network operation and scalability. - Initiate development, integration, test and simulation of the full function network technologies that exploit diverse paths and frequencies to support network scalability and network formation of tens of thousands of operational nodes.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Investigate the integration of the DARPA Interference Multiple Access (DIMA) waveform onto the WNaN system. - Build, integrate and test pre-production WNaN radios with final version of advanced full function network technologies. - Conduct demonstration of pre-production WNaN radios in a field test that forms a highly adaptive, dynamic, self-forming, self-healing WNaN military tactical network. - Transition WNaN program to the Army.					
Networked Bionic Sensors for Threat Detection (U) The Networked Bionic Sensors for Threat Detection program will develop and demonstrate low power micro-sensor devices and networks for multiple missions including, language/speech detection and recognition processing, and shooter localization. The system will use ultra-low power signal conditioning/processing front-end processors with advanced algorithms for distributed sensor network applications. This program will provide the ability to discretely monitor buildings, human presence detection/tracking in other sensitive areas, enable force protection, and provide battle damage information. Intelligence, surveillance, and reconnaissance (ISR) capabilities will be enhanced with this technology by allowing detection and tracking of high-value targets with hand emplaced or air deployed sensor networks. The technology developed is planned for transition to the U.S. Marine Corps. *FY 2009 Accomplishments:* - Developed a system architecture to exploit network of low-power micro-sensor devices. - Developed algorithms for acoustic micro-sensor network exploitation for threat detection. *FY 2010 Plans:* - Conduct system design trades of power vs. performance sensitivity and accuracy. - Design a brassboard system for field environments. - Build prototype systems for operational evaluation.	1.000	2.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM)	3.000	4.000	5.000	0.000	5.000

(U) The Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) program will pursue MIMO communication systems, which have the potential to increase data rates by 10-20 times above current systems. MIMO will use multipath to create parallel channels in the same frequency band thereby increasing spectral efficiency. This effort will demonstrate the MNM capability under dynamic urban Non-Line-of-Sight multipath channel conditions where conventional techniques are degraded. This effort will undertake advanced MIMO technology development and perform field demonstrations of mobile ad hoc networks (MANETs). This effort will culminate in the development of a wideband form-factor system for use in tactical edge devices including troops, vehicles, and robotics. The MNM technology is planned for transition to the Army in FY 2011.

FY 2009 Accomplishments:
- Developed, integrated, and tested high risk enhanced network technologies that exploit diverse paths and frequencies to support network scalability and network formation to support large numbers of tactical nodes.
- Developed, integrated, tested and demonstrated MNM wideband interference mitigation technology.
- Performed demonstrations at military locations demonstrating mobile, airborne, urban, and rural capabilities and improvements over current single input, single output (SISO) systems.

FY 2010 Plans:
- Design nodes that will be able to be employed in various devices, including robotics, mobile, and/or advantaged devices.
- Show the ability to scale to a large number of network nodes while providing an order of magnitude improvement in reliability over related SISO systems.
- Demonstrate a communication system where the network layer can mitigate shortfalls in the physical layer in a live many-node demonstration.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Design, build, test, and demonstrate MIMO capabilities into a handheld/body wearable multi-channel radio that utilizes high volume, low cost COTS RF circuits, narrowband tuning filters and dual-core Digital Signal Processing baseband processing. *FY 2011 Base Plans:* - Perform a transition demonstration in an operational environment.					
Mobile Ad Hoc Interoperability Networking GATEway (MAINGATE) (U) Building upon gateway technology developed under the WNaN and Future Combat Systems (FCS) Communications program, the Mobile Ad hoc Interoperability Networking GATEway (MAINGATE) program seeks to develop the next generation Network Centric Radio System (NCRS) with additional capabilities and an assured affordable unit price to the user. MAINGATE will enable heterogeneous groups of radios to be integrated into a heterogeneous network tolerant to high latency and packet loss. The technologies developed for the program will permit affordable, tactical, real-time, high fidelity video, data, and voice services to be deployed in a networked environment to support tactical operations in maneuver or dismounted operations for line-of-site and beyond-line-of-site communications on the move and at the halt. Two critical technologies for achieving these goals: 1) a backbone radio architecture that enables a versatile IP Mobile Ad hoc Network (MANET) and 2) a radio gateway that enables legacy analog and digital communications systems to be interconnected through a network. The MAINGATE program will use an iterative build-test-build approach that will culminate with limited user testing by U.S. and Allied Experimental Forces evaluating the affect of MAINGATE on new tactics, techniques and procedures designed for the networked maneuver and dismounted forces. The resulting MAINGATE system and capability is planned for transition in 2011 to the U.S. Army and Marine Corps with a focus on Special Operations Forces. *FY 2009 Accomplishments:* - Completed demonstrations of an initial, interoperable gateway capability.	22.652	6.000	7.000	0.000	7.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiated development of the wireless MANET capability and demonstrated an adaptive IP backbone network among gateways. - Conducted basic gateway and MANET performance in fielded environment. - Completed design of prototype MAINGATE units for field experimentation and testing. - Conducted two capability demonstrations to Army personnel. Demonstrations included up to 10 MAINGATE nodes (air and ground) providing interoperability among 15 radio types. - Began integrating dynamic spectrum access (DSA) and disruption tolerant networking (DTN) technologies into the MAINGATE system. *FY 2010 Plans:* - Develop and demonstrate the final gateway capability for interoperability between all targeted legacy networks. - Develop and demonstrate the final wireless MANET capability to create an adaptive IP backbone network among gateways and for connection to the Global Information Grid (GIG). *FY 2011 Base Plans:* - Perform limited user testing of the MAINGATE units in a realistic tactical scenario. - Transition the MAINGATE capability to the Military Services.					
Next Generation Communications (U) The Next Generation Communications program will develop detection and "reasoner" technology that will allow cognitive radios to recognize jamming attacks and then adapt to maintain communications in the presence of cognitive jammer attacks and dynamic interference of multiple cognitive network interactions. The program will develop models of adversary, commercial, and friendly cognitive radios and implement those models in a "reasoner" that assesses, in real time, the current and future dynamics of the communications network. Based on the predictions of the level of communication success vs. mission communication requirements, the "reasoner" within the cognitive radio will choose waveform selections/configurations that best achieve mission objectives.	0.000	0.000	6.000	0.000	6.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
The "reasoner" will include the capability to analyze and select optimum waveform configurations during all aspects of a mission, to include initial alert, ingress, mission, and infiltration. The design effort will lead to new radio communication architectures, more robust radio communication networking and better understanding of selection amongst interference avoidance and interference suppression strategies based on the predicted outcome. (U) The Next Generation Communications will result in an original capability to predict communications performance in a complex electromagnetic environment that includes large numbers of emitters and various types of Red/Blue/White communication systems. These predictions will enable cognitive radios to select the optimum communications configuration for achieving success given the mission phase and objective. This program will also develop and construct a network of radios that implement interference alignment, solving practical design issues such as distributed synchronization. *FY 2011 Base Plans:* - Develop and demonstrate algorithms to measure cognitive radio network behaviors that sufficiently characterize state space and behavior. - Establish baseline sensor performance requirements. - Analyze/develop efficient model structure, essential metrics, and transforms. - Initiate development of attack library to include interface specifications, and baseline attack detectors. - Conduct concept design studies and perform feasibility analysis for moderate and large networks. - Develop efficient distributed algorithms and implement hardware prototypes for carrier frequency offset and frame synchronization. - Develop efficient algorithms for channel estimation and computation and distribution of alignment information; design the associated protocols.					
Polarized Rotation Modulation (PZRM) Communications	1.000	0.000	0.000	0.000	0.000

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The goal of the Polarized Rotation Modulation (PZRM) Communications program was to develop new extremely high data rate, point-to-point, or point-to-multipoint wireless communications waveform using the PZRM/Orthogonal Signal Spectrum Overlay (OSSO) communications concept to exploit the presently unused polarization and rotation dimensions of radiation. The PZRM Communications program investigated the use of polarization, including OSSO, modulation and the ability for conventional radios to carry all information over the transmitted signal amplitude, phase and frequency. The program demonstrated as an enhancement to an otherwise state-of-the-art communications system. Technologies developed under this program are available for transition to the Services in FY 2009. *FY 2009 Accomplishments:* - Completed final assessment of technology.					
Next Generation (XG) (U) The Next Generation (XG) program developed both the enabling technologies and system concepts to provide dramatic improvements in assured military communications in support of a full range of worldwide deployments through dynamic spectrum access. U.S. Forces face unique spectrum access issues in each country in which they operate due to competing civilian or government users of national spectrum. These constraints must be reflected in all force planning and may preclude operation of critical systems. Coalition and allied operations are even more complex to manage, and may severely limit the U.S. ability to fully exploit its superiority and investment in information technology. The XG program developed the theoretical underpinnings for dynamic access to the spectrum, the technologies and subsystems that enable dynamic access, and the system prototypes to demonstrate applicability to legacy and future DoD radio frequency emitters. The program investigated methods to leverage the technology base in microelectronics with new waveform and medium access and control protocol technologies to construct an integrated system. The program developed, integrated, and evaluated the technology to enable equipment to automatically select spectrum and operating modes to both	2.250	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
minimize disruption of existing users, and to ensure operation of U.S. systems. The XG program also developed and demonstrated a set of standard dynamic spectrum adaptation technologies for legacy and future emitter systems for joint service utility. The XG communications technology transitioned to the Army for implementation in a range of current and future communication systems including the Joint Tactical Radio Systems clusters and the Enhanced Position Location and Reporting System - Extended Frequency (EPLRS-XF) radio systems. *FY 2009 Accomplishments:* - Initiated effort with the U.S. Army to integrate XG software into the EPLRS-XF military networking radio. - Conducted assessment of EPLRS-XF processing and memory requirements for hosting the XG software. - Developed the software architecture of XG algorithms in the EPLRS-XF system. - Conducted modeling and simulation to verify changes to networking protocols.					
Advanced Speech Encoding (ASE) (U) The Advanced Speech Encoding (ASE) program achieved an order of magnitude reduction of voice communication bit rates over current state-of-the-art voice encoders (VOCODER) in noisy military environments. Such a reduction significantly decreased the probability of detection of transmitted signals and also decreased the required transmit energy, thereby increasing battery lifetime. The program pursued two novel approaches toward achieving its goal. Multiple noise-immune sensors combined with traditional coding algorithms; and communication without acoustic information achieved by extracting laryngeal and sublingual muscle signals that are produced when a person generates sub-vocal speech. The ASE technology is transitioning to the Special Operations Command and the Communications and Electronics Command of the U.S. Army.	4.350	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Collected two large-scale libraries ("corpora") of mouth and neck electromyographic (EMG) signals for sub-vocal speech and signal models that relate the EMG signals to the mouthed but unspoken words. - Developed an ASE prototype, conducted tests, and demonstrated EMG-based sub-vocal word recognition. - Established that five EMG sensors can be used with negligible loss (vice eleven sensors) in system performance.					
Conflict Modeling, Planning, and Outcomes Experimentation (COMPOEX) (U) The Conflict Modeling, Planning, and Outcomes Experimentation (COMPOEX) research effort developed technologies that enhance the capability of leaders to plan and conduct complex campaigns. This includes a comprehensive suite of decision support tools that help leaders with: visualizing and understanding the situation and the complex operational environment they must operate in; constructing and managing plans that enable the commander to synchronize and integrate interdependent effects over a long period of time; employing the best sequence of unified actions to produce the desired effects; and generating and exploring options and courses of action to understand the range of outcomes and appreciate the side effects that may occur. Technologies developed in the program are transitioning to the U.S. Pacific Command (PACOM) and the Office of the Secretary of Defense Cost Analysis and Program Evaluation (OSD CAPE). *FY 2009 Accomplishments:* - Completed final PACOM demonstration. - Completed the transition to OSD CAPE as one of their analytical tools.	1.000	0.000	0.000	0.000	0.000
DARPA Interference Multiple Access (DIMA) Communications	4.049	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The DARPA Interference Multiple Access (DIMA) Communications program developed a networked radio system that supports voice, video and data. The program developed a network that is dynamically controllable using techniques such as reconfiguration, optimum resource allocations based on mission priorities, and dynamic policies, as opposed to relatively passive reactions to changes by the commercial infrastructure. This program initially developed direct sequence spread spectrum (DSSS) communications technologies as a building block to enable robust, mobile, tactical wireless networks, which are the foundation for network centric warfare concepts. The fundamental technical challenges are scalability, multi-user detection processing, low probability of detection/low probability of interception (LPD/LPI), robustness and platform size, weight and power (SWAP) requirements. The DIMA Communications program then developed and demonstrated a system based on multi-user detection (MUD) concepts that take advantage of overloaded channels while operating in an environment absent of infrastructure (ad-hoc networked). The technologies developed under this program are transitioning to the Army and USMC. *FY 2009 Accomplishments:* - Reduced complexity of DIMA system. - Developed and demonstrated real-time DIMA in a mobile ad hoc network using a radio handheld platform. - Tested the network in scenarios relevant to tactical users. - Transitioned DIMA technologies to the Army and USMC.					
Accomplishments/Planned Programs Subtotals	163.681	91.301	64.376	0.000	64.376

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CCC-CLS: *CLASSIFIED*	93.092	88.195	85.983	0.000	85.983	68.575	99.978	132.458	137.283	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) in the Special Access Program Annual Report to Congress.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Classified DARPA Program This project funds Classified DARPA Programs. Details of this submission are classified. *FY 2009 Accomplishments:* Details will be provided under separate cover. *FY 2010 Plans:* Details will be provided under separate cover. *FY 2011 Base Plans:* Details will be provided under separate cover.	93.092	88.195	85.983	0.000	85.983
Accomplishments/Planned Programs Subtotals	93.092	88.195	85.983	0.000	85.983

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	PE 0603765E: *CLASSIFIED DARPA PROGRAMS*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	193.690	177.582	167.008	0.000	167.008	314.719	239.335	225.567	238.565	Continuing	Continuing
CLP-01: *CLASSIFIED DARPA PROGRAMS*	193.690	177.582	167.008	0.000	167.008	314.719	239.335	225.567	238.565	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) in the Special Access Program Annual Report to Congress.

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	196.164	186.526	0.000	0.000	0.000
Current President's Budget	193.690	177.582	167.008	0.000	167.008
Total Adjustments	-2.474	-8.944	167.008	0.000	167.008
• Congressional General Reductions		-0.744			
• Congressional Directed Reductions		-8.200			
• Congressional Rescissions	-2.474	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• TotalOtherAdjustments	0.000	0.000	167.008	0.000	167.008

Change Summary Explanation

FY 2009

Decrease reflects the Section 8042 rescission of the FY 2010 Appropriations Act.

FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts.

FY 2011

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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Not Applicable

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Classified DARPA Programs	193.690	177.582	167.008	0.000	167.008
Classified DARPA Programs *FY 2009 Accomplishments:* Details will be provided under separate cover. *FY 2010 Plans:* Details will be provided under separate cover. *FY 2011 Base Plans:* Details will be provided under separate cover.					
Accomplishments/Planned Programs Subtotals	193.690	177.582	167.008	0.000	167.008

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010

APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	133.138	138.361	234.985	0.000	234.985	220.099	224.850	190.625	190.435	Continuing	Continuing
NET-01: *JOINT WARFARE SYSTEMS*	46.148	50.765	71.175	0.000	71.175	64.380	55.393	40.352	40.312	Continuing	Continuing
NET-02: *MARITIME SYSTEMS*	16.920	32.677	41.682	0.000	41.682	54.639	62.612	35.570	35.535	Continuing	Continuing
NET-CLS: *CLASSIFIED*	70.070	54.919	122.128	0.000	122.128	101.080	106.845	114.703	114.588	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Network-Centric Warfare Technology program element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to develop and rapidly mature advanced technologies and systems required for today's network-centric warfare concepts. It is imperative for the future of the U.S. forces to operate flawlessly with each other, regardless of which services and systems are involved in any particular mission. The overarching goal of this program element is to enable technologies at all levels, regardless of service component, to operate as one system.

(U) The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly expanded capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents utilizing systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often collocated, and in peacekeeping operations where combatants and civilians are often indistinguishable. Meeting these challenges places a heavy burden on joint war planning. Understanding opponent networks is essential so that creative options can be developed to counter their strategies. Synchronization of air and ground operations to apply force only where needed and with specific effects is required.

(U) The Maritime Systems project will identify, develop and rapidly mature critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Naval forces play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea and their versatile ability to provide both rapid strike and project sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces.

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	154.015	135.941	0.000	0.000	0.000
Current President's Budget	133.138	138.361	234.985	0.000	234.985
Total Adjustments	-20.877	2.420	234.985	0.000	234.985
• Congressional General Reductions		-0.580			
• Congressional Directed Reductions		-12.000			
• Congressional Rescissions	-14.572	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-1.978	0.000			
• SBIR/STTR Transfer	-4.327	0.000			
• Congressional Restoration for New Starts	0.000	15.000	0.000	0.000	0.000
• TotalOtherAdjustments	0.000	0.000	234.985	0.000	234.985

Change Summary Explanation

FY 2009

Decrease reflects Section 8042 rescission of the FY 2010 Appropriations Act, SBIR/STTR transfer and internal below threshold reprogramming.

FY 2010

Increase reflects the FY 2010 Congressional Restoration for New Starts offset by reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts.

FY 2011

Not Applicable

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
NET-01: *JOINT WARFARE SYSTEMS*	46.148	50.765	71.175	0.000	71.175	64.380	55.393	40.352	40.312	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly increased capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents using systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often co-located, and in peacekeeping operations where combatants and civilians are often indistinguishable. Meeting these challenges places a heavy burden on joint war planning. Understanding opponent networks is essential so that creative options can be developed to counter their strategies. Synchronization of air and ground operations to apply force only where needed and with specific effects is required. This project supports all levels of the force structure including: (1) the strategic/operational level by generating targeting options against opponents' centers of gravity that have complex networked relationships; (2) the tactical/operational level by managing highly automated forces with tight coupling between air and ground platforms; and (3) the focused tactical level by developing platforms and tools, which acquire targets of opportunity and cue network-based analysis of likely enemy operations thus maximizing the effectiveness of ground forces in stability and support operations.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Geospatial Exploitation (GEO) (U) The Geospatial Exploitation (GEO) thrust will provide a new set of geospatial intelligence (GEOINT) products, continuously updated and maintained in a form that ensures their consistency across both product elements (digital elevation models, traditional maps, 3-D structure models, census summaries, and directories) and spatial nodes (coarse resolution country data for economic analysis to fine resolution building data for platoon-level combat operations). Techniques of interest include model-based image analysis (both object recognizers and change detectors), symbolic correlators (both temporal and spatial), and emerging cognitive methods to identify changes to	4.000	3.351	1.500	0.000	1.500

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
objects, addresses, names, and functions of natural and human-made structures. These algorithms will be scaled to operate on data streams including full-motion video, Laser Identification Detection and Ranging (LIDAR), multi- and hyper-spectral, synthetic aperture radar (SAR), and Geographic Information Systems (GIS) in addition to conventional electro-optical (EO) geospatial imagery. GEO algorithm architectures will be explored to achieve scalability through spatial, temporal and ontological partitioning. GEO technologies are planned for transition to the National Geospatial-Intelligence Agency (NGA). Activities funded within the GEO research space include: • The Urban Reasoning and Geospatial Exploitation Technology (URGENT) program is developing a 3-D urban object recognition and exploitation system that enables advanced mission planning and situation analysis capabilities for the warfighter operating in urban environments. URGENT will create techniques for the rapid exploitation of EO and LIDAR sensor data at the city scale to recognize urban objects down to the soldier scale. URGENT will apply image processing technology to geospatially registered 2-D/3-D data collected from airborne and terrestrial sources, yielding precise annotations for the objects in an urban area. URGENT will also develop a 3-D reasoning engine to query object shapes, locations, and classifications for advanced geospatial exploitation capabilities. • The Geospatial Representation Integrated Dataspace (GRID) program is developing an automated geospatial data fusion, modeling, and dissemination system from national assets for the tactical warfighter. Geospatial registration algorithms will automatically fuse geospatial data from multiple sources including EO, LIDAR, SAR, and hyperspectral - and encode the fused data as a temporally indexed volumetric model that drastically reduces geospatial data storage requirements while enhancing image quality. Updates will propagate to the model using a compressed geospatial data format capable of reaching the warfighter even with the bandwidth constraints of tactical networks. *FY 2009 Accomplishments:* Urban Reasoning and Geospatial Exploitation Technology (URGENT)					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrated automated object recognition capability on fused EO and LIDAR data from aerial and terrestrial urban sources. - Evaluated speed and accuracy of performance of automated object recognition in comparison with the performance of human geospatial analysts. Geospatial Representation Integrated Dataspace (GRID) - Demonstrated volumetric encoding of LIDAR, electo-optical and hyper-spectral data from national assets showing a reduction in data storage relative to the raw data without impacting performance. - Demonstrated the volumetric encoding of non-optical (e.g., SAR) data with optical data. - Validated through qualitative simulation that GRID technology increases troop movement rates and reduces casualties. *FY 2010 Plans:* Urban Reasoning and Geospatial Exploitation Technology (URGENT) - Develop capability for rapid retraining on one or more new geospatial areas and object classes. - Develop interactive user environment for military geospatial exploitation. - Begin the process of transition of selected object recognition technology to a military geospatial analysis environment. Geospatial Representation Integrated Dataspace (GRID) - Increase the compression ratio of volumetric data compared to raw geospatial source data. - Develop the ability to detect changes in the geometry and surface properties of the urban terrain. - Develop the ability to plan paths and analyze road network trafficability through complex urban terrain using fused geospatial data. *FY 2011 Base Plans:* Urban Reasoning and Geospatial Exploitation Technology (URGENT)					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Implement a reasoning capability that exploits knowledge from Geographic Information System (GIS) documents. - Complete the process of transition of selected object recognition technology to a military geospatial analysis environment. Geospatial Representation Integrated Dataspace (GRID) - Demonstrate the volumetric encoding of electro-optical and LIDAR data from tactical as well as national assets. - Develop the ability render fused geometric models into realistic 3D gamelike environments. - Develop the ability to propagate changes to the dataspace throughout a distributed system on a network with severe bandwidth constraints.					
Network Command (U) The Network Command program leverages recent advances in network computing, simulation, and visualization to dramatically improve collaboration among physically separate command posts and lower echelons. Network Command enables warfighters to share situation information and exploited data from the area of responsibility, develop coordinated battle plans, generate and compare alternate courses of action, and assess likely outcomes, without conventional group briefings. Network Command also enables warfighters to prepare for joint missions using high-fidelity, mixed-reality combat simulation and visualization technologies. • The Network-Centric Situation Assessment program develops and deploys technologies to assess military situations at levels of interest above individual targets. The program uses all-source data to reconstruct unit organizations, mission relationships, logistics connections, and communications connectivity and analyzes data over time to infer movement, communication, and supply patterns. Within this context, capability analyses are provided and future courses of action are hypothesized. The objective is to understand potential capabilities and intentions of opposing forces. This effort provides greater understanding of opponents' force structures, capabilities, and operational practices,	3.000	1.889	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and then enables commanders to sustain effects-based targeting rather than simple attrition strategies. The program provides a context for discovering vulnerabilities in opposing forces and provides cues for intelligence, surveillance, and reconnaissance planning, as it suggests areas of future enemy activity that merit intense scrutiny. Technologies are planned to transition to the U.S. Army. • The Joint Mission Rehearsal program integrates high-fidelity, mixed-reality combat simulations with situation assessment and planning tools. The objective is to allow rehearsal of joint missions, prior to actual engagements. The visualization permits the warfighter to interact with both reality and the simulation simultaneously in a manner consistent with their anticipated role in the mission. The program delivers the capability to practice and fine-tune mission plans for joint military operations and enables commanders and staff to participate from their current location instead of a training facility, thereby reducing deployment needs while improving mission planning and effectiveness. Technologies are planned to transition to the U.S. Army Simulation, Training & Instrumentation Command, United States Special Operations Command (USSOCOM), and the Marine Corps Combat Development Command (MCCDC). *FY 2009 Accomplishments:* Network-Centric Situation Assessment - Completed system design and analysis. Joint Mission Rehearsal - Evaluated simulation technology for use in Army/Marine tactical scenarios. - Evaluated technology for use of synthetic Opposition Forces (OPFOR) within the real world-training environment. *FY 2010 Plans:* Joint Mission Rehearsal - Design a system for use in Platoon level mission rehearsal and planning.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Demonstrate in a simulated urban training environment with presentation of synthetic opposition forces (OPFOR).					
Mobile Intelligent Sensors (MIS) (U) There is particular interest in exploiting new legged, wheeled, and tracked robots to create “robot-enabled sensors” that are capable of sensing, moving, and self-organizing into a viable network for reliable data exfiltration. The Mobile Intelligent Sensors (MIS) program and the Remote Detection of Suspicious Vehicles (RDSV) program are developing such advanced sensor, exploitation, networking, and battle management capabilities for joint dismounted forces. These nodes will have a sufficient level of embedded intelligence so that they can identify, learn, adapt, and traverse through or under small openings and circumnavigate barriers larger than themselves, yet be capable of carrying an operationally-meaningful day/night sensor payload. Envisioned payloads include EO/IR for day/night imaging and video surveillance/monitoring and acoustic/vibration sensing to obtain information such as foot and vehicular traffic, operation of mechanical systems, gunfire, excavation activities, etc. Technologies are planned to transition to the U.S. Army, U.S. Special Operations Command, and the U.S. Marine Corps. *FY 2009 Accomplishments:* Mobile Intelligent Sensors (MIS) - Created system definition, concept of operations, and operational scenarios. - Developed payload size, weight, and power requirements (SWAP) and assessed the feasibility of alternative approaches. - Defined signal processing requirements and identified algorithmic approaches. - Collected data for offline performance analysis. Remote Detection of Suspicious Vehicles (RDSV) - Executed transition experiments and system development of field deployable prototypes with the U.S. Army, the U.S. Marine Corps, and other Agencies.	2.000	1.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
- Demonstrated system performance in major PACOM exercise in a joint environment. - Executed transition to military use in current military theater of operations. *FY 2010 Plans:* Mobile Intelligent Sensors (MIS) - Develop sensors meeting SWAP requirements. - Implement algorithms and integrate a prototype signal processor. Remote Detection of Suspicious Vehicles (RDSV) - Complete transition activities with the U.S. Army, U.S. Marine Corps, and other Agencies.					
Seismic/Acoustic Vibration Imaging (SAVI) (U) The Seismic/Acoustic Vibration Imaging (SAVI) program will develop the capability to locate both buried landmines and near-surface tunnels using active acoustic and seismic sources coupled with a multi-pixel laser vibrometer. These systems will employ well characterized acoustic and seismic sources to stimulate the targets of interest from a remote platform. Focused acoustic sources will be employed to remotely stimulate plastic or metal antipersonnel and antitank mines. A laser vibrometer system will be used to detect the stimulated resonant characteristic of the mines to discriminate against natural sources of clutter. Similarly, the interaction of near-surface seismic waves with tunnels and other objects will be observed with a multi-pixel laser vibrometer system and used to assess the depth and extent of the targets in the midst of natural and man-made clutter. The systems developed under this effort will be tested against a wide variety of soil types and environments to support operations under a wide range of conditions. Upon successful development of the initial and objective systems, the capabilities will be transitioned to the Army and Marine ground forces for the development and employment of operational systems starting in FY 2011.	16.618	7.954	1.416	0.000	1.416

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Completed the development of the component technologies required by the scalable system demonstration. - Completed the development of high speed data processing capability to support realtime detection of buried landmines. - Initiated scalable system integration for mobile detection demonstration. - Initiated the development of the scalable brassboard system for mobile operations. *FY 2010 Plans:* - Complete scalable system integration for mobile buried landmine and static near surface tunnel detection. - Complete scalable system outdoor demonstration of acoustic landmine hunting and limited seismic tunnel testing. - Initiate scaled system development to improve coverage rate and standoff distance. *FY 2011 Base Plans:* - Demonstrate final scaled system for Active Acoustic Landmine and Active Seismic Tunnel Detection with 1000+ pixel laser vibrometer. - Initiate transition to Army and Marines.					
Multipath Exploitation Radar (MER) (U) The Multipath Exploitation Radar (MER) program will address radar deficiencies in urban operations: limited line of sight due to urban structures and excessive confusers due to multipath reflections. This program will exploit multipath bounces to detect and track moving targets beyond line-of-sight (LOS), and extend the area coverage rate of airborne sensors by a factor of six or more over physical line-of-sight limits. If successful, the urban coverage improvement will make it cost effective to consider airborne surveillance of an area the size of a large metropolitan area with a handful of airborne	5.185	4.000	2.240	0.000	2.240

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
sensors. This capability will facilitate both manned and unmanned airborne Intelligence, Surveillance and Reconnaissance (ISR) and is planned to transition to the Air Force and Army in 2011. *FY 2009 Accomplishments:* – Collected representative field data in urban environment using COTS radar to validate multipath phenomenology and support algorithm concept development. – Validated physics of specular multipath radar returns in collected representative field data. *FY 2010 Plans:* - Develop and validate urban target and clutter signature models accounting for non-line-of-site propagation. - Develop urban tracking algorithms that predict, detect, and incorporate multipath radar returns using knowledge of the urban terrain. - Document modeling and algorithm performance against urban collected field data. *FY 2011 Base Plans:* - Determine upper bounds on track accuracy, persistence, and target density that can be achieved using NLOS returns. - Develop system concept for persistent wide-area surveillance over large metropolitan areas using multiple platforms. - Quantify the radar hardware and processing requirements to implement MER and identify potential transition platforms. - Transition Multipath Exploitation Radar system to the Services.					
Human-carried Explosive Detection Stand-off System (HEDSS) (U) Insurgent and terrorist elements are increasingly relying on human carried explosives because they are nearly impossible to visibly detect. The goal of the Human-carried Explosive Detection Stand-off System (HEDSS) program is to develop a system that can rapidly and automatically identify human-	6.200	2.500	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
carried explosives (HCEs) at stand-off ranges. While alternative technologies exist for HCE detection, they necessitate close-in sensing, are expensive and require extended processing times. Successful development of a HEDSS will provide reliable protection for deployed forces from suicide bombers by allowing enough time and space to interdict bombers before they cause maximum damage. The technology is planned for transition to the Army, Air Force and Marines. *FY 2009 Accomplishments:* - Developed preliminary design of HEDSS production model. - Determined by analysis a unit cost versus the number of models purchased and production unit performance estimates. - Measured a reduced set of targets of interest in a controlled environment using a scaled down version of the system. *FY 2010 Plans:* - Conduct extensive field testing and performance analysis.					
Multi Dimensional Mobility Robot (MDMR) (U) The Multi Dimensional Mobility Robot (MDMR) program investigated concepts using serpentine mobility to achieve new ground robot capabilities for search and rescue applications. Examples of these capabilities include: overcoming obstacles that are a significant fraction of its length, crossing slippery surfaces, ascending poles, climbing steep slopes, and optically sensing its immediate surroundings. *FY 2009 Accomplishments:* - Demonstrated field capable performance.	1.000	0.000	0.000	0.000	0.000
Network Targeting	5.145	12.260	15.910	0.000	15.910

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Network Targeting program will develop advanced capabilities for a specified emitter density, operating environment, RF signal location accuracy, probability of correct RF signal identification and probability of false alarm. Each phase will progressively mature the design and technologies required to achieve system performance goals and move incrementally toward an operational system. The technology is planned to transition to the Services in FY 2013. *FY 2009 Accomplishments:* - Performed system design. - Collected data for algorithm development, testing and evaluation. *FY 2010 Plans:* - Develop components and software for a system. - Conduct performance validation via laboratory demonstrations in a controlled operational environment. *FY 2011 Base Plans:* - Demonstrate real-time processing on brassboard hardware. - Conduct performance validation via demonstrations in a higher-complexity operational environment.					
Legged Squad Support System (LS3) (U) The Legged Squad Support System (LS3) program will explore the development of a mission-relevant quadruped platform scaled to unburden the infantry squad and hence unburden the soldier. In current operations, soldiers carry upwards of 50lbs of equipment, in some cases over 100lbs, over long distances in terrain not always accessible by wheeled platforms that support infantry. As a result, the soldier's combat effectiveness can be compromised. The LS3 program will design and develop prototypes capable of carrying 400lbs of payload for 20 miles in 24 hours, negotiating terrain at endurance levels expected of typical squad maneuvers. LS3 will leverage technical breakthroughs of prior biologically inspired legged platform development efforts. It will develop system designs to	3.000	8.000	16.083	0.000	16.083

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
the scale and performance adequate for infantry squad mission applications, focusing on platform, control, and human-machine interaction capabilities, as well as secondary design considerations, such as acoustic signature. Multiple technical approaches will be explored, including electromechanical and hydraulic methods of legged actuation. Anticipated service users include the Army, Marines and Special Forces. *FY 2009 Accomplishments:* - Developed, analyzed and assessed preliminary designs to achieve a system capable of twenty miles of endurance in a twenty-four hour (unrefueled) period, carrying a 400lb payload. - Simulated gait selection, execution, and transitioning. *FY 2010 Plans:* - Build subsystems that prove design validity. - Model foot placement, stability against disturbances, and self-righting. - Conduct subsystems testing and results analysis. *FY 2011 Base Plans:* - Complete critical design review and integration plan; initiate demonstration system fabrication. - Complete initial integration of controls to demonstrate walk and trot. - Integrate perception hardware.					
Cave Dog (U) The Cave Dog program will provide an alternative to visual, infrared and millimeter wave radar imaging for environments in which obscurants are used that limit the imaging capability of these systems. Cave Dog will provide an acoustics-based imaging capability. By sensing reflected sound waves and combining the low resolution acoustic imaging data with architectural and contextual models of the environment, an approximate representation of the area surrounding a soldier may be developed, allowing a soldier to identify walls, doorways, and people. Cave Dog will provide the soldier with	0.000	0.000	1.214	0.000	1.214

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
knowledge of his environment in conditions of total darkness and in the presence of smoke, dust, or other airborne particles. The Cave Dog program will focus on developing sensors as well as the software required to provide real-time processing of acoustic array data and algorithms to develop a representation of the surrounding environment based on the coarse imagery provided by the acoustic sensor and models of architectural and structural elements of the surrounding environment. *FY 2011 Base Plans:* - Conduct analysis of available sensor technologies and perform algorithm development. - Demonstrate static sensor capability for acoustic detection of walls and doorways in a room.					
High Energy Liquid Laser Area Defense System (HELLADS) (U) Building upon the achievements of the HELLADS development program budgeted in DARPA PE 0602702E, Project TT-06, the goal of the High Energy Liquid Laser Area Defense System (HELLADS) program is to develop a high-energy laser weapon system (150 kW) with an order of magnitude reduction in weight compared to existing laser systems. With a weight goal of <5 kg/kW, HELLADS will enable high-energy lasers (HELs) to be integrated onto tactical aircraft and will significantly increase engagement ranges compared to ground-based systems, enable high precision, low collateral damage, and rapid engagement of fleeting targets for both offensive and defensive missions. With the assistance of the U.S. Air Force, the HELLADS program will pursue the necessary analysis, coordination, and design activity for a prototype laser weapon system incorporating the HELLADS laser system into a test aircraft. *FY 2011 Base Plans:* - Design suitable physical and functional aircraft interfaces for the prototype system. - Develop test plans and procedures; analyze, procure, and prepare suitable target systems and test range environments. - Conduct necessary modeling and simulation for system performance and target interactions.	0.000	0.000	25.000	0.000	25.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-01: *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
- Coordinate other activities necessary for safe and effective operation of the prototype system on the test aircraft.					
Chemical Analysis Sans Machinery (CASM) (U) The Chemical Analysis Sans Machinery (CASM) program will develop novel materials and fabrication methods to produce high throughput, autonomous, low cost, chemical analysis devices. *FY 2010 Plans:* - Develop novel materials and technologies with unique chemical analysis properties. - Fabricate materials with high throughput for chemical analysis. - Fabricate materials for chemical analysis, amenable to low cost manufacturing. *FY 2011 Base Plans:* - Fabricate materials with more rapid response time for chemical analysis. - Fabricate materials that are more reliable and sensitive for chemical analysis. - Integrate novel materials and technologies into chemical analysis devices.	0.000	9.811	7.812	0.000	7.812
Accomplishments/Planned Programs Subtotals	46.148	50.765	71.175	0.000	71.175

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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency			**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-02: *MARITIME SYSTEMS*	

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
NET-02: *MARITIME SYSTEMS*	16.920	32.677	41.682	0.000	41.682	54.639	62.612	35.570	35.535	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The objective of the Maritime Systems project is to identify, develop and rapidly mature critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Improvements in communications between and among submarines, surface ships and naval aircraft have allowed these forces to operate seamlessly with each other and with other Service's network centric systems. Naval forces will play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea and their versatile ability to provide both rapid strike and project-sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Persistent Ocean Surveillance (POS) (U) The Persistent Ocean Surveillance (POS) program combines geolocation techniques such as the global positioning system with station keeping and intra-sensor communication technologies to provide long-term ocean environment sensing buoys. These technologies, when applied with state-of-the-art undersea warfare sensors, will result in a floating field of smart sensors capable of observing the undersea environment in an area, including the presence of submarines and other undersea vehicles. A range of technologies have been considered including those that rely on the local environment (such as wind, ocean waves, solar energy, temperature differentials, etc.) for their power, miniature geolocation technologies, and technologies for sensor data storage, transmission, and intra-field communications. The Renewable At-Sea Power program focuses on efficient energy capture from the environment in order to achieve capability for fully renewable power at sea. Technology from this program will be available for transition to the U.S. Navy.	2.250	1.850	1.000	0.000	1.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Conducted design study of efficient energy capture for long endurance capability. - Integrated energy harvesting systems and conducted at sea testing. - Developed computer simulation models. *FY 2010 Plans:* - Build instrumented platform to test improved endurance and survivability in high sea conditions. - Conduct at-sea testing to validate performance of technologies and system models. *FY 2011 Base Plans:* - Integrate technologies into demonstration platform.					
River Eye (U) Early entry maritime forces need maps of morphology, water depths, and currents in complex riverine/estuarine environments for mission planning and execution. This information is critical for route planning, sensor placement, rendezvous determination, vulnerability assessments, and determining objective assault engagement/disengagement strategies. For uncharted and/or denied areas, present methods are inadequate for obtaining the necessary information. Reliable remote sensing methods do not exist that produce bathymetry and water current data in waters that are sediment laden (bottom not visible) and/or sheltered (swell and significant wind waves are not likely). The River Eye effort will provide a new capability to predict or assess, in real time, river and estuary conditions to enable special operations mission planning and execution. New techniques will be developed to indirectly determine current speed and direction by remotely sensing advection of scene features. Using advanced modeling techniques, indirectly sensed current data will be used to extract bathymetry data. Forward circulation models will use the bathymetry data to predict future currents and water heights in a mission planning decision support tool. The River Eye effort is anticipated to transition to the Navy and National Geospatial-Intelligence Agency.	3.082	3.025	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Refined algorithms for extracting circulation currents and bathymetry in more complex environments. - Performed data collections over diverse rivers and estuaries. - Compared currents derived from River Eye algorithms to currents measured by acoustic Doppler current profilers and both were in agreement. - Continued development of the inverse model for extracting bathymetry from indirectly sensed currents. - Demonstrated highly accurate estimation of water depth and channel locations. *FY 2010 Plans:* - Improve the automation of the current extraction algorithms and inverse model to handle clouds and moving objects in the time series data. - Develop a variable grid size to improve current resolution. - Develop capability to identify shoals. - Apply inverse model to new physical environments and improve the efficiency of the model. - Demonstrate the inverse model to obtain bathymetry in an unknown environment. - Transition River Eye current and bathymetry algorithms to the Navy and National Geospatial-Intelligence Agency.					
Tango Bravo (U) Based on the results of the DARPA/Navy Submarine Design Study, the Tango Bravo technology demonstration program is exploring design options for a reduced-size submarine with equivalent capability of the VIRGINIA Class submarine. The implicit goal of this program is to reduce platform infrastructure and, ultimately, the cost of future design and production of submarines. The program is a collaborative effort to overcome selected technological barriers that are judged to have a significant impact on submarine platform and infrastructure cost. DARPA and the Navy, under a Memorandum of Agreement, jointly formulated technical objectives for critical technology demonstrations in: 1) shaftless	5.669	6.177	4.632	0.000	4.632

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
propulsion, 2) external weapons stowage and launch, 3) conformal alternatives to the existing spherical sonar array, 4) radical ship infrastructure reduction technologies that eliminate or substantially simplify hull, mechanical and electrical systems, and 5) automated attack center technologies to reduce crew manning. (U) Anticipating success of shaftless propulsion technologies demonstrated in the Tango Bravo program, DARPA and the U.S. Navy initiated a Memorandum of Agreement in 2008 with the goal of designing, building, and testing a large scale Submarine Shaftless Stern Demonstrator (S3D) to characterize and mitigate risks associated with ship integration into a next generation submarine propulsion option. The S3D program will now focus on full-ship concept studies and the Tango Bravo Shaftless Propulsion technical risk reduction activities will conclude in FY 2011. Elements of the Tango Bravo program began transition to the Navy in FY 2009, with full transition now anticipated at the conclusion of the Shaftless Propulsion project in FY 2010. *FY 2009 Accomplishments:* - Concluded testing of the electric actuator, including approximately one million full cycles of the actuator under representative at-sea dynamic loadings and pressures, completing the Radical Ship Infrastructure Reduction project. - Completed concept studies for S3D. *FY 2010 Plans:* - Complete Shaftless Propulsion demonstrator assembly. - Complete Shaftless Propulsion technical risk reduction integration tasks on S3D. *FY 2011 Base Plans:* - Complete Shaftless Propulsion integrated system testing (in-air, full load motor testing). - Complete Shaftless Propulsion in-water acoustic and endurance testing.					
Maritime Persistent Surveillance and Awareness (MPSA)	1.419	2.100	0.000	0.000	0.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(U) The Maritime Persistent Surveillance and Awareness (MPSA) program will develop an extensible battle management automation capability to provide persistent surveillance and situational awareness to protect naval forces against overwhelming threats. MPSA will use layered and distributed sensing, and add data from all sources for the non-traditional areas of infrastructure, socio-political developments and economic indicators. These systems will enable timely and coordinated decision-making and vastly improved situational awareness under uncertainty for naval commanders. MPSA will enable intelligent deployment of sensors and network infrastructures to protect sea-based assets through effective cross-platform and multi-mission fusion and resource management with focus on stand-off and elusive threats. Automated tracking with intelligent fusion and classification, and assimilation of non-traditional information sets are of particular interest. This will require bringing additional processing power to bear, allowing implementation of complex processing algorithms. MPSA will also enable the decoupling of intelligence, surveillance, and reconnaissance/defense missions from offensive missions, improving the power projection capability of the deployed force. MPSA will depart from previous approaches in assessing the operational environment in that it will not rely solely upon military indicators, but will also expand understanding to include national infrastructure, socio-political, and economic indicators to better assess trends and threat development. The program will transition to the Navy. *FY 2009 Accomplishments:* - Developed system concepts to assimilate and process data from all sources to detect changes in national infrastructure, socio-political climate and economic indicators that could affect adversary military capacity and capabilities. *FY 2010 Plans:* - Develop methodologies to assess effectiveness of component technologies through modeling and simulation.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop system architectures for assimilation and processing of classified and open source data to detect militarily relevant changes in a nation's physical infrastructure, socio-political climate and economic indicators. - Develop advanced human-computer interaction techniques to optimize human/machine performance for the naval commander.					
Blue Laser for Submarine Laser Communications (SLC)	4.500	10.025	21.550	0.000	21.550
(U) The Blue Laser for Submarine Laser Communications (SLC) program will develop the critical laser technology necessary to support the requirements for non-acoustic Anti-Submarine Warfare (ASW), mine detection, and SLC. SLC and non-acoustic ASW programs are intended to develop the world's first wall-plug efficient laser that operates both at an optimum water transmission band of open ocean water and at the wavelength of a Cesium Atomic Line Filter. There is a pressing need for improved ASW capabilities in the current operating environment, particularly in shallow water (above the thermocline) and littoral areas of operations. This laser has the potential to enable duplex communications for the submarine at unrestricted speeds and deep depths and improve the detection depth of a non-acoustic anti-submarine warfare lidar system by a significant factor. A Memorandum of Agreement (MOA) was signed among DARPA, Commander, Submarine Forces (COMSUBFOR), Deputy Chief of Naval Operations for Integration of Capabilities and Resources (N8), and Program Executive Officer, Command, Control, Communications, Computers and Intelligence (PEO C4I). The MOA establishes a joint program to conduct a demonstration of the SLC technology during a recognized fleet exercise in FY 2012. The Blue Laser technology is planned for transition to the Navy. *FY 2009 Accomplishments:* - Designed, built and tested a power amplifier module to verify performance optically and thermally at high power. - Commenced development of a breadboard blue solid state laser with improved wall-plug efficiency. - Completed compatibility testing of breadboard blue solid state laser with Cesium (Cs) atomic line filter.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Complete design, build, and test of the breadboard blue solid state laser. - Demonstrate laser / filter capability in a laboratory environment. - Commence detailed design of flight brassboard transmitter. - Commence optical, mechanical and electrical designs. - Build and test optical, mechanical and electrical subassemblies for integration into the brassboard transmitter. - Commence building, integration, and testing of amplifier modules into a full power output subsystem. - Commence integrating the laser module transmitter with the receiver module. *FY 2011 Base Plans:* - Complete building, integration, and testing of amplifier modules in a full power output subsystem. - Deliver, test and demonstrate flight brassboard transmitter for wavelength, energy per pulse, repetition rate, beam quality, pulsewidth, and wall-plug efficiency necessary for SLC and non-acoustic ASW.					
Thermal Management System for Ship Decks (TMD) (U) It is anticipated that the high engine exhaust temperatures from the next generation of Vertical Take Off and Landing (VTOL) aircraft deployed on navy ships will dramatically reduce the life of both the deck structure and the non-skid surfaces. The Thermal Management System for Ship Decks (TMD) will address this problem by demonstrating a heat distribution system with an integrated thermally stable non-skid coating. Upon satisfactory completion of the development and certification of the design, the TMD will be transitioned to the Navy for integration into amphibious assault ships. *FY 2010 Plans:* - Develop and construct scaled modular passively cooled thermal management system.	0.000	3.500	4.000	0.000	4.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Conduct assessment of thermo physical properties of non-skid coatings and develop thermally resistant non-skid coating. - Develop and construct a small-scale, non-skid, coated, passively cooled thermal management system. - Provide thermal management design and computational assessment to the Navy.					
Deep Sea Operations (DSOP) (U) The Deep Sea Operations program will achieve game changing advantages through operations in the deep ocean exploiting maritime persistent surveillance and communications technologies. The deep ocean offers the ability to distribute, conceal and protect maritime assets and operations that today are readily described as concentrated, exposed, and vulnerable. The unfavorable extreme conditions of pressure, temperature, and signal propagation challenge the ability to operate in this frontier. Breakthroughs are needed in several areas: 1) Development of energy and power for persistence and propulsion, including energy harvesting, energy delivery, and solutions for air-independent propulsion; 2) Development of alternatives for through-water communications for high-bandwidth data exfiltration and command and control; and 3) Development of new sensing modalities to exploit unique signatures and deep ocean conditions, including overcoming acoustic aperture constraints through advanced synthetic aperture sonar or virtual laser-defined hydrophones for high resolution detection and classification. Success will lead to systems that capitalize on these breakthroughs to provide high payoff capability relevant to anti-submarine warfare, infrastructure protection, shore monitoring, and forward staging operations. The program will transition to the Navy. *FY 2010 Plans:* - Conduct simulation and trade space analysis. - Conduct at-sea data collection supporting signature characterizations, processing development and feasibility assessments.	0.000	6.000	10.500	0.000	10.500

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiate design of sub-system architectures. *FY 2011 Base Plans:* - Design multiple configurable systems. - Develop key subsystems and conduct any necessary in water testing. - Collect additional signature and environmental data needed to support technology designs.					
Accomplishments/Planned Programs Subtotals	16.920	32.677	41.682	0.000	41.682

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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	NET-CLS: *CLASSIFIED*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
NET-CLS: *CLASSIFIED*	70.070	54.919	122.128	0.000	122.128	101.080	106.845	114.703	114.588	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) in the Special Access Program Annual Report to Congress.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Classified DARPA Program This project funds Classified DARPA Programs. Details of this submission are classified. *FY 2009 Accomplishments:* Details will be provided under separate cover. *FY 2010 Plans:* Details will be provided under separate cover. *FY 2011 Base Plans:* Details will be provided under separate cover.	70.070	54.919	122.128	0.000	122.128
Accomplishments/Planned Programs Subtotals	70.070	54.919	122.128	0.000	122.128

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-CLS: *CLASSIFIED*

E. Performance Metrics

Details will be provided under separate cover.

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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603767E: *SENSOR TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	182.583	222.866	205.032	0.000	205.032	251.805	251.131	242.589	252.392	Continuing	Continuing
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	63.703	50.619	42.286	0.000	42.286	49.658	64.231	64.123	64.404	Continuing	Continuing
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	118.880	99.486	82.541	0.000	82.541	87.179	87.211	90.095	92.986	Continuing	Continuing
SEN-03: *EXPLOITATION SYSTEMS*	0.000	33.455	51.807	0.000	51.807	68.148	61.407	59.407	56.013	Continuing	Continuing
SEN-CLS: *Classified*	0.000	39.306	28.398	0.000	28.398	46.820	38.282	28.964	38.989	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Sensors Technology program element is budgeted in the Advanced Technology Development Budget Activity because it funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability and battle damage assessment.

(U) The Surveillance and Countermeasures Technology project will exploit recent advances in multispectral target phenomenology, signal processing, low-power high-performance computing and low-cost microelectronics to develop advanced surveillance and targeting systems. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with tactical information needed to succeed in future wars. Additionally, this project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats.

(U) The Sensors and Processing Systems project develops and demonstrates advanced sensors, and exploitation technologies. These efforts provide warfighters with situational awareness and precision target identification. The project is driven by four needs: 1) integrating data from multipath sources into consistent situational assessments; 2) providing near-real-time, semi-automatic exploitation of wide-area moderate and high-resolution imagery; 3) obtaining real-time, accurate battle damage assessment; and 4) accomplishing robust, precise identification, precision fire control tracking and engagement of ground targets.

(U) The Exploitation Systems project develops algorithms, software, and information processing systems to extract information from massive intelligence, surveillance, and reconnaissance (ISR) datasets. In particular, it develops new technologies for detection and discrimination of targets from clutter, classification and fingerprinting of high value targets, localization and tracking over wide areas, and threat network identification and analysis.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	214.582	243.056	0.000	0.000	0.000
Current President's Budget	182.583	222.866	205.032	0.000	205.032
Total Adjustments	-31.999	-20.190	205.032	0.000	205.032
• Congressional General Reductions		-0.934			
• Congressional Directed Reductions		-19.256			
• Congressional Rescissions	-1.044	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-24.926	0.000			
• SBIR/STTR Transfer	-6.029	0.000			
• TotalOtherAdjustments	0.000	0.000	205.032	0.000	205.032

Change Summary Explanation

FY 2009

Decrease reflects Section 8042 rescission of the FY 2010 Appropriations Act, Omnibus Reprogramming action for the H1N1 vaccine development, SBIR/STTR transfer and internal below threshold reprogramming.

FY 2010

Decrease reflects reductions for the Section 8097 Economic Assumption, execution delays and FY 2010 new starts.

FY 2011

Not Applicable

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603767E: *SENSOR TECHNOLOGY*	**PROJECT** SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	63.703	50.619	42.286	0.000	42.286	49.658	64.231	64.123	64.404	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This project funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability, and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a clandestine manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, low-power high-performance computing, and low-cost microelectronics to develop advanced surveillance and targeting systems. In addition, this project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Low-Altitude Airborne Sensor System (LAASS) (U) The Low-Altitude Airborne Sensor System (LAASS) program is developing an airborne sensor system to find and characterize underground facilities (UGFs) used to shield and protect strategic and tactical activities, including command and control, weapons storage, and manufacture of weapons of mass destruction (WMD) and tunnel networks that breach secure borders and perimeters. By passively capturing emissions associated with underground facility presence and operations, and doing so using airborne sensors (acoustic, electromagnetic, gravity gradiometry), LAASS can significantly increase our ability to seek out underground facilities and map out their vulnerabilities and backbone structure. LAASS technologies are planned to transition to Northern Command, Southern Command, Strategic Command, or Defense Threat Reduction Agency in FY 2013.	12.226	3.490	5.559	0.000	5.559

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Completed gravity gradiometry system requirements for tactically useful tunnel detection capability. - Completed evaluation of candidate sensor technologies for development of gravity gradiometer prototype evaluation system. - Produced system design and initiated development of gravity gradiometer prototype evaluation system. *FY 2010 Plans:* - Develop algorithm concepts and operational CONOPS for the confident detection of tunnels in the presence of geologic clutter, defined as natural structures that have properties similar to tunnels. - Explore the potential of alternative technologies to mitigate geologic clutter and reduce false alarms. - Complete development of gravity gradiometry sensor suite and perform major system design trades. *FY 2011 Base Plans:* - Validate, through modeling and laboratory tests, that existing gravity gradiometry sensor technologies and all supporting subsystems can be successfully adapted to meet Gravity Anomaly for Tunnel Exposure (GATE) system requirements and detection performance. - Document expected performance of system concept (sensor, installation, processing). - Develop high-risk, critical-path components (e.g. sensor and sensor isolation). - Validate that high-risk components can be fabricated which meet required system specifications for detection performance. - Generate system design (preliminary and critical) for capability on tactical platform. - Develop prototype payload and integrate onto a tactical air vehicle.					
Airborne Tomography using Active Electromagnetics (ATAEM) (U) The Airborne Tomography using Active Electromagnetics (ATAEM) program is developing an active electromagnetic (EM) system for airborne imaging of subsurface structures, such as underground facilities (UGFs) or perimeter-breaching tunnels. The ATAEM system illuminates the ground with	6.136	6.971	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
electromagnetic energy and interprets resulting distortions of the electric and magnetic fields to detect and characterize surreptitious structures. The ATAEM program will investigate and develop the component technologies, including EM illumination sources, noise-isolated sensor payloads and signal processing. ATAEM developed technology is expected to be available for transition to the U.S. Army, U.S. Marine Corps, and U.S. Special Operations Command in FY 2010. *FY 2009 Accomplishments:* - Integrated low-noise sensor suite into helicopter tow pod. - Investigated and developed off-board electromagnetic illumination sources. - Completed testbed development and integration, and documented system specifications. - Collected and analyzed operationally relevant airborne data over multiple targets of interest as a function of operational parameters (illumination sources, flight parameters). - Identified and documented deficiencies in the system concept for EM sources and sensor payload noise floor that impacted realizable testbed performance. *FY 2010 Plans:* - Expand and evaluate range of technologies and signatures through modeling and focused field collections to establish feasibility for close-access missions such as tactical tunnel detection. - Develop an integrated system model for predicting the performance of alternative system concepts supported by field measurements. - Develop mitigation strategy using multiple technologies to negate false detections caused by geologic clutter. - Develop system requirements for multiple technology concept.					
Strategically Hardened Facility Defeat (U) Building upon the successes of technology developed under the Counter Underground Facilities program, the Strategically Hardened Facility Defeat program will continue to develop alternative earth-penetrating technologies for the defeat of strategically hardened targets. The threat posed by the	12.404	7.481	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
proliferation of hard and deeply buried targets with major strategic capabilities around the world is increasing dramatically. These strategically hardened facilities are used to harbor our adversaries' most dangerous assets including leadership bunkers, command and control functions, and weapons of mass destruction. However, because the size and weight of traditional earth penetrating weapons scale exponentially with the depth of the facility, current warhead penetration depths are and always will be insufficient to reach many of these targets. As a result, a strategic capability gap exists and new approaches to earth penetration and warhead delivery are needed. This program leverages recent advances in earth-penetrating technologies for full defeat of strategically hardened facilities at depths inaccessible to traditional earth penetrating weapons. Technology developed under this program will be available for transition to the Defense Threat Reduction Agency (DTRA) in FY 2010. *FY 2009 Accomplishments:* - Integrated advanced penetration and energy supply technologies. - Demonstrated penetration, energy and deployment capabilities through field trials. - Developed sensing and navigation capabilities. *FY 2010 Plans:* - Design and initiate development of deployable system with advanced penetration and navigation capabilities.					
Lightning Based (Sferic) Underground Geo-positioning (U) The Lightning Based (Sferic) Underground Geo-positioning program will address the challenges presented when navigating and tracking within underground structures, both manmade and natural, by exploiting the abundance and long propagation range of naturally occurring global lightning events. As conceived, surface receivers at known locations will compare time difference of arrival of very low frequency (VLF) sferic events and employ super-resolution correlation techniques to accurately determine the VLF source locations. Any subsurface receiver will also detect the sferics, and real time or post-mission correlation with the surface data will enable geo-location of the subsurface receiver.	2.000	8.256	6.543	0.000	6.543

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Exploitation of naturally-occurring, nondeniable signals has the potential to significantly reduce logistical requirements and increase operational standoff by orders of magnitude (1000+ km). Transition to U.S. Special Operations Command (SOCOM) and the U.S. Army is anticipated by FY 2012. *FY 2009 Accomplishments:* - Acquired global signal availability data as function of geographic coordinates and time, for determination of operational constraints on sferics-based navigation. - Conducted field tests to determine geolocation accuracy with varying geologic overburdens. - Revised and validated models for propagation of sferics over long distances (100s to 1000s of km) to support mission planning and performance prediction. *FY 2010 Plans:* - Develop and demonstrate non-real time geolocation of an underground user in the field. - Develop and demonstrate through-the-earth (TTE) communications for navigation (surface-to-subsurface communications) and tracking (subsurface-to-surface communications) scenarios. - Design prototype hardware for subsurface receivers and processors and TTE communications. - Evaluate potential for integration of global lightning receiver network data into the sferic system. *FY 2011 Base Plans:* - Demonstrate above ground to below ground TTE communications for navigation (surface-to-subsurface communications) and scenarios. - Build and test prototype hardware (receiver and processors) for sferic-based geopositioning and navigation.					
Visibuilding (U) The Visibuilding program is developing technologies and systems for new building surveillance capabilities to detect personnel within buildings, determine building layouts, and locate weapons caches within buildings. This program is developing techniques to inject and recover probing radar	15.970	20.271	11.184	0.000	11.184

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
waveforms and unravel the complicated multipath in the return signals to enable the mapping and characterization of building interiors. Radar signals are being used to image static structures directly. Doppler processing of radar signals is also being exploited to find, identify, and perform feature-aided tracking of moving personnel within a building and allow mapping of building pathways and stairways by monitoring traffic through buildings. Multipath and propagation effects are modeled and iteratively compared with hypotheses of building structures to provide 3-D building maps and large concentrations of metal materials like weapons. Other sensing modalities and component technologies are concurrently being investigated that offer the possibility of providing complementary information about the layout of large buildings as well as their associated underground areas. Component pieces will transition to the Army's Program Executive Office (PEO) Intelligence, Electronic Warfare & Sensors (IEWS) and U.S. Special Operations Command. *FY 2009 Accomplishments:* - Designed and built fieldable instrumentation radar systems for collection from airborne, vehicle, and emplaced platforms. - Performed developmental and blind test collection on two-story, unfurnished buildings and quantified system floor plan reconstruction and insurgent localization. - Began investigation of alternative sensing technologies for interior layout and associated underground structures. *FY 2010 Plans:* - Develop system design for a radar-based system to meet metric for determining floor plan and insurgent tracks within 30 minutes. - Develop radar design and processing techniques to mitigate radar clutter experienced in realistic urban environments (e.g. from furniture). - Develop and model performance of multiple alternative sensing approaches.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete demonstrations of radar-based prototype system and quantify ability to determine building layout and track insurgents within furnished multi-story buildings. - Complete and evaluate concept development for ability of alternative sensing modalities to contribute to above-ground and below-ground layout. - Identify validated alternative sensing modalities for continued development. - Transition radar-based system to U.S. Army and U.S. Special Operations Command.					
Rescue Transponder (RT) (U) Building upon technologies developed in other sensor programs, the Rescue Transponder (RT) program will investigate the use of a unique localization and tracking technology to provide a very low probability of detection (LPD) call for help signal. The system will use a wide band radio frequency signal with low power and extremely low duty cycle. The goals of the RT program are to develop a small, rugged transponder that provides a call for help to friendly forces. The RT system will operate over ranges that enable rescue forces or surveillance systems to receive its signals. It will support accurate localization by rescue forces, and permit transmission of identifying, authenticating, and status information. The RT technology is planned for transition to the U.S. Marine Corps in 2010. *FY 2009 Accomplishments:* - Evaluated deployable unit performance in U.S. Marine Corps EXERCISE Talisman Saber 2009. - Developed and conducted field experiments in support of U.S. Marine Corps initial end-user field evaluations. - Researched enhancements to support system performance capabilities for military use. - Initiated design of enhanced version of RT to allow improved calibration and synchronization. *FY 2010 Plans:* - Develop advanced prototypes with self-calibration and non-synchronization tag capabilities to simplify operations.	2.217	2.150	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop and conduct field experiments to support major U.S. Marine Corps operational field exercise. - Complete transition between DARPA and U.S. Marine Corps.					
Combat Laser Infrared Countermeasure (IRCM) Proactive Survivability System (CLIPSS) (U) The Combat Laser Infrared Countermeasure (IRCM) Proactive Survivability System (CLIPSS) will enable air dominance at low altitude and at night against infrared missile threats in the form of man portable air defense (MANPAD) systems, adjunct missile guidance systems and advanced infrared search and track systems, based on proactive infrared countermeasures (PIRCM). Leveraging the systems and focal plane array (FPA) technology development established by the Multifunction Electro-Optics for Defense of U.S. Aircraft (MEDUSA) program (budgeted in PE 0603768E, Project GT-01) in the near infrared, mid-wave infrared, and potentially the long-wave infrared bands of the optical spectrum and the reactive directed infrared countermeasures (DIRCM) capabilities currently in the field, CLIPSS will provide a near term demonstration and transition of the proactive capability and serve as a pathfinder for the longer range, all band objectives of MEDUSA. The primary technical obstacles of this approach will be the continued development and integration of high sensitivity infrared Focal Plane Array (FPA) and multi-frequency laser technologies into compact, efficient packages for demanding IRCM environments. The real-time processing of the range resolved laser returns over wide fields of view to rapidly cue the proactive countermeasures poses a significant systems integration challenge as well and will be addressed by this demonstration. CLIPSS Technology is planned to transition to the Services in FY 2014. *FY 2009 Accomplishments:* - Completed study analysis of potential system performance based on emerging sensor technology supporting the PIRCM application.	3.000	2.000	2.000	0.000	2.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Complete the design of airborne breadboard system(s) to demonstrate proactive IRCM to support clutter rejection algorithms. - Initiate design and modeling of integrated Proactive IRCM / Directed IRCM pod-based demonstration system. *FY 2011 Base Plans:* - Initiate key laser and optical technology development to support detailed design objectives. - Complete key technology demonstrations to support objective system designs. - Complete airborne breadboard PIRCM data collection. - Validate performance modeling to support critical design for integrated pod-based PIRCM / DIRCM system.					
Robust Surface Navigation (RSN) (U) The Robust Surface Navigation (RSN) program (previously funded under PE 0603768E, Project GT-01) will provide the U.S. warfighter with the ability to navigate effectively when the Global Positioning System (GPS) is unavailable due to hostile action (e.g. jamming) or blockage by structures and foliage. The RSN program will use Signals of Opportunity (SoOP) from a variety of ground, air, and space-based sources, augmented by judiciously placed RF beacons; these will be received on the Warfighter's forthcoming software defined radios and use specially tailored algorithms to determine position. The greater strength and diversity of these signals will provide coverage when GPS is denied due to environmental conditions or hostile activity. This is a two-part program: (1) cataloging and assessing potential exploitable signals followed by analysis and performance modeling and hardware-based concept validation, and; (2) designing, testing, and demonstrating a (non-form-fit) prototype receiver(s) and algorithms for geolocation using the SoOP. The RSN technology is planned for transition to the U.S. Special Operations Command and the U.S. Army with specific elements of the program transitioning to the U.S. Navy and U.S. Air Force in FY 2011.	0.000	0.000	7.000	0.000	7.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Conduct field tests and demonstrate the functional RSN prototype in user-selected environments such as forested, jungle and open environments, and for airborne platforms. - Transition RSN technology.					
Global Tactical ISR (U) The Global Tactical ISR program will develop technologies to provide tactical-grade ISR with coverage scalable from the local to the global, to address issues of global importance. Our forces must conduct military operations with exquisite precision across an expansive theater of operations like the Pacific Ocean, in addition to highly specific locations such as a building in a densely populated urban area. The ISR that supports this wide range of operations needs to be correspondingly precise and accurate at rates typical of tactical operations, as well as meet salient requirements such as operate through jamming. New technologies are needed that address the demanding challenges presented by tactical-level ISR with geographic coverage extending from the extremely broad to the ultra narrow. These technologies include new signal sources for probing the environment, receivers, algorithms, and sensors in general. The program will result in fundamentally new technology approaches. For example, the application of commercial technologies to military problems often results in signature or performance compromises that need to be re-examined to enable the maximum benefit to the warfighter. Specific examples include a pulsed fiber-laser that pushes existing peak-power system limitations may be developed for rapidly deployable long-range laser radar systems, as well as a mid-IR laser sources for biological and chemical detection applications. Stand-off detection of special nuclear material at distances greater than 1 km may be enabled by a novel X-ray source. New engineering approaches to be developed by the program may include enhancing the performance of existing airborne and space-borne sensors through novel algorithms that minimize the need for costly new flight hardware. Thermal inertia imaging, and other technologies when combined with the advanced data processing may yield solutions to persistent problem sets such as underground facility detection and tunnel detection. Revolutionary new sensing modalities may enable the acquisition of new signatures	0.000	0.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
to enhance our intelligence collection. The overriding objective of this program is the development of sensor technologies that enable ISR for local areas of operation typical of the brigade-level and below, as well as for the global and regional coverage needed by the Combatant Commands. This program plans to transition to the Services FY 2015. *FY 2011 Base Plans:* - Identify alternative concepts for revolutionary signal sources, receivers, algorithms and/or sensors for global tactical ISR. - Establish proof-of-concept for global tactical ISR technologies. - Initiate development of prototypes.					
Assured Operations in High Latitudes (U) The Assured Operations in High Latitudes program will develop technologies to assure operations in the extreme environment typical of high latitudes, which has the challenges of ice, snow, permafrost, weather, and unique ionspheric/magnetospheric phenomena. The focus of current operations for U.S. forces is primarily in mid-latitudes, with existing systems and technologies optimized for use in these latitudes. The high latitudes of the Arctic comprise an emerging operational domain for which new technologies are needed. (U) Mapping the extent and thickness of the sea ice in the Arctic is fundamental to operations in this region. Current technologies exist for the wide area mapping of the extent of the Arctic sea ice, e.g., satellite-based synthetic aperture radar, but the mapping of the thickness of the ice relies primarily on electro-magnetic induction point measurements above the ice followed by interpolations between these points, which is a very slow process. The program will develop technology for rapid, wide area mapping of ice thickness to determine where to surface through the ice, as well as chart courses through the ice. This technology will build upon space- and/or aircraft-based millimeter-wave radar (based on technologies developed under the MEO-SAR program budgeted under PE 0603287E, Project SPC-01),	0.000	0.000	5.000	0.000	5.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
shore- and/or ship-based HF surface radar, upward-looking sonar on fixed or mobile nodes, and new modeling methods. Enhancing situational awareness for U.S. forces in the Arctic is an additional benefit of the mapping technology to be developed by the program. (U) The program will also develop technologies that will enable a navigation and communication infrastructure for future platforms and sensors operating under the Arctic ice. This infrastructure includes leave-behind, through-ice nodes that act as beacons and communication ports, low-power trans-Arctic acoustic transmitters for GPS-like navigation, and navigation via scene mapping relying on detailed bottom bathymetry. The through-ice nodes will need to generate sufficient thermal power to melt through the ice, and advances in miniature combustion engines provide one path to achieve this goal that is superior to past failed efforts using chemical reactions and batteries. Long-baseline acoustics for GPS-like navigation has never been done, but recent scientific work on low-power, flow-frequency sound propagation to measure ocean temperatures suggests feasibility. This program plans to transition to Navy, Air Force, Marines, and Army in FY 2015. *FY 2011 Base Plans:* - Develop conceptual designs for revolutionary technologies to enhance rapid mapping of ice thickness and/or navigation and communication beneath the ice for high latitude operations. - Establish proof-of-concept for technologies to rapidly map ice thickness and/or navigate and communicate beneath the ice for high latitude operations.					
Speckle Exploitation for Enhanced Reconnaissance (SEER) (U) The Speckle Exploitation for Enhanced Reconnaissance (SEER) program provided long-range, non-cooperative identification of moving/stationary targets using incoherent scattered laser speckle reflected off a target surface. Laser speckle has reduced sensitivity to adverse turbulence-induced distortion and so provides a viable signal at ranges exceeding those projected for other active laser systems. Technical achievements under other programs in this PE/Project provided the basis	6.000	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
for radically new approaches to measuring target characteristics under conditions that limit the performance of conventional sensors. Target characteristics potentially obtainable may include target image, shape, size, structural features, and other advanced threat properties. By extending the operating range of current active electro optic sensors, SEER enabled the friendly platform to stand off from the maximum operating range of hostile sensors/weapons, while executing the targeting task and directing weapons against targets. *FY 2009 Accomplishments:* - Developed algorithms that reliably and uniquely associate target signatures with speckle patterns. - Implemented algorithms using optical Micro Electro-Mechanical systems (MEMs) or other related technologies to achieve reduced size, weight and power.					
Cross-Border Tunnel (CBT) (U) The Cross-Border Tunnel (CBT) program investigated technologies and systems to detect small tunnels used to breach security perimeters and national borders. The program goal was to develop innovative technologies inspired by geophysical exploration techniques that detect and characterize these threat tunnels while simultaneously satisfying operational considerations such as search rate, site access, monitoring persistence, and exposure of friendly forces. The initial CBT program thrust performed collections of seismic and electromagnetic (EM) data at a test bed using current state of the art sensors from the geophysical industry. (U) The program’s recent focus was on a Fast-Scan CBT detection technique. This technique investigated developing a tunnel detection system focused on providing a fast linear scan rate, for operationally tractable protection of large controlled areas or national borders. Current subterranean interrogation techniques based on geophysical exploration methods have the combined impediments of slow interrogation rate, need for complete site access, or exposure of forces. Contrary to invasive imaging methods, the Fast-Scan concept would provide rapid detection of anomalous subsurface	3.750	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
structures consistent with voids. Technical challenges included: 1) identification of optimal detection strategies, source characteristics, and sensor geometries, 2) rejection of clutter with length scales similar to tunnels or response from non-threat structures (utilities), and 3) technology migration to a moving platform. This study completed and data transitioned to the Services in FY 2009. *FY 2009 Accomplishments:* - Completed study to determine the design requirements for the source characteristics and sensor/ source geometry that optimizes the detection performance.					
Accomplishments/Planned Programs Subtotals	63.703	50.619	42.286	0.000	42.286

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 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	118.880	99.486	82.541	0.000	82.541	87.179	87.211	90.095	92.986	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Sensors and Processing Systems project develops and demonstrates the advanced sensor and processing technologies and systems necessary for military's intelligence, surveillance, and reconnaissance (ISR) missions. Future battlefields will continue to be populated with targets that use mobility and concealment as key survival tactics, and high-value targets will range from specific individual insurgents and vehicles to groups of individuals and large platforms such as mobile missile launchers and artillery. The Sensors and Processing Systems project is primarily driven by four needs: (a) providing day-night ISR capabilities against the entire range of potential targets; (b) countering camouflage, concealment and deception of mobile ground targets; (c) detecting and identifying objects of interest/targets across wide geographic areas in near-real-time; and (d) enabling reliable identification, precision fire control tracking, timely engagement and accurate battle damage assessment of ground targets. The Sensors and Processing Systems project develops and demonstrates technologies and system concepts that combine novel approaches to sensing with emerging sensor technologies and advanced sensor and image processing algorithms, software, and hardware to enable comprehensive knowledge of the battlespace and detection, identification, tracking, engagement and battle damage assessment for high-value targets in all weather conditions and combat environments.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Network Centric Sensing and Engagement	5.015	3.426	0.000	0.000	0.000
(U) The Network Centric Sensing and Engagement program develops technology and tools to support precise small unit situational awareness, rapid targeting, and precision engagement in highly-networked environments. Network-centric sensing acknowledges a group of sensors as a system and leverages networked intercommunication to enable system performance superior to that of uncoordinated individual sensors. The program uses organic reconnaissance, surveillance and target acquisition data to update tactical users and planners over multiple echelons with critical environmental and operational information. Required technology advances include: sensor-to-sensor communications, multi-sensor management, sensor system georegistration, real-time data fusion, advanced tracking, and network-					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
centric sensor operational modes. Technologies are planned to transition to small tactical units in irregular operations. *FY 2009 Accomplishments:* - Evaluated the effect of combining multiple organic sensor updates on situation assessment for rapid military riverine operations. *FY 2010 Plans:* - Evaluate the effect of combining multiple semi-autonomous organic sensor updates and novel display technologies on situation assessment for rapid military riverine operations.					
Advanced Radar Sensor Technology (U) The Advanced Radar Sensor Technology thrust develops radar systems to provide significant improvements in our ability to detect, identify, and track surface targets and threats over very wide areas in all climatic conditions. Program efforts focus on exploiting emergent and novel RF sensing technology and phenomenology. Key elements are advancements in ultra-wide band, bistatics, UHF/VHF, emitter location and direction-finding, polarimetric change detection, tomographic imaging, space-time adaptive processing and other advanced signal processing, advanced Ground Moving Target Indicator (GMTI) techniques, and foliage, building, and ground-penetrating radar phenomenology. Program developments are integrated with current and emerging military platforms, including small and micro UAVs, with emphasis on the most stressing military radar sensor challenges. Examples are operations featuring complex cluttered ground environments; those against small and slow moving surface targets; urban operations, and situations where camouflage, decoys and countermeasures must be overcome. Programs in this thrust include: • The Next Generation RF Antenna System program will develop and demonstrate a light-weight wide-band RF antenna that enables high gain over a broad frequency range and signal detection at extended ranges. This program is planned for transition to the U.S. Air Force.	6.124	6.396	0.000	0.000	0.000

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• The Airborne Passive Direction Finding with a Tactical Vector Sensor (ATVS) program will develop and demonstrate a compact, lightweight, airborne, real-time, tactical emitter detection and location system suitable for tactical UAVs. This program is planned for transition to the U.S. Army.

• The Efficient Digitization of Element Signals program will exploit new and emerging techniques in signal coding and compressive sensing to allow large, element-count, radio frequency (RF) arrays to be digitally sampled using small numbers of receivers. Technologies are planned for transition to the Navy, Army and Air Force.

FY 2009 Accomplishments:

Next Generation RF Antenna System
- Refined electromagnetic models.
- Fabricated and measured RF properties.
- Demonstrated non-reciprocity with real meta-materials and showed agreement with models.

FY 2010 Plans:

Next Generation RF Antenna System
- Design a novel antenna with superior gain and bandwidth.
- Validate design using electromagnetic modeling.
- Commence fabrication of first prototype antenna.

Airborne Passive Direction Finding with a Tactical Vector Sensor (ATVS)
- Develop prototype ATVS antenna and measure RF performance characteristics in an outdoor range.
- Design complete ATVS system.

Efficient Digitization of Element Signals

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Develop general compressive sampling techniques which exploit sparsity in RF signal space and/or time. - Use a combination of signal coding and sample selection to allow the element signals to be received and sampled by a small number of digital receivers and to recover the original element signals digitally through a combination of decoding and interpolation.					
NetTrack* *Previously part of Advanced Radar Sensor Technology. (U) DARPA's NetTrack Program is developing feature aided tracking technologies to enable airborne surveillance radars to maintain track on moving High Valued Targets (HVTs) in traffic and cluttered environments. Ground Moving Target Indicator (GMTI) radars provide excellent potential for tracking high value targets because they operate in all weather and at long ranges. However, maintaining target tracks is very challenging because obscuration and close target spacing make it difficult to associate radar kinematic measurements over time. To address this challenge, NetTrack is developing feature aided tracking technology that automatically collects and exploits target high range resolution (HRR) radar measurements. Specific NetTrack technologies include signal processing to generate HRR measurements from raw radar returns, feature extraction and matching to exploit HRR measurements, multiple hypothesis tracking to associate measurements to tracks and estimate target location and velocity, and sensor resource management to automatically select optimum radar mode parameters and timing sequences. Technologies are planned for transition to the Navy, Army and Air Force. *FY 2009 Accomplishments:* - Demonstrated radar signature-aided vehicle tracking. - Tested initial NetTrack capabilities in an operational airborne radar system. *FY 2010 Plans:* - Demonstrate NetTrack capabilities in real-time on operational radar platform.	9.970	7.890	2.000	0.000	2.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Complete demonstration of NetTrack capabilities. - Transition to the U.S. Services.					
Advanced Airborne Optical Sensing	5.933	13.576	16.379	0.000	16.379
(U) The Advanced Airborne Optical Sensing program develops electro-optical and infrared sensors and surveillance for aerial platforms. Significant challenges arise as the result of two warfighting trends. First, the ever-changing mix of airborne platforms now includes a greater number of smaller UAVs. Second, the target set is increasingly challenging and now includes vehicles and individual dismounts that operate under foliage and in urban canyons, using camouflage, obscurants, and other means of concealment. In response to these challenges, the Advanced Airborne Optical Sensing program brings recent advances in optical, electro-optical, photonic and other technologies to airborne optical sensing systems. Specific examples of these technologies include: embedded image processors tailored to real-time detection, identification, and tracking of military targets; hyper-spectral sensing technologies; flash detection, and underwater object detection; advanced laser radar technologies; advanced digital signal processing to support onboard image reconstruction, atmospheric correction, and system calibration; video exploitation techniques, including new approaches to scene understanding and activity detection; and adaptive optics techniques, such as deformable mirrors and liquid crystal spatial light modulators. The program extends these technologies and makes them practical for airborne surveillance systems. Efforts in this program include: • The Standoff Precision ID in 3-D (SPI 3-D) program is developing an affordable sensor package capable of high-resolution 3-D images for confirmatory target ID at long ranges as well as full field of view (FOV) ranging to support precise geolocation of targets. The system provides intensity, range and polarization information for each pixel in the field of view with each laser pulse. The program includes a series of ground-based and airborne demonstrations of SPI 3-D precision ID capabilities and track fusion techniques. The objectives are to provide: (1) high range resolution 3-D imaging;					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
(2) full FOV range to pixel determination; (3) multiple frame-to-frame registration of imagery, and (4) GPS-based cueing from search systems. Results will provide commanders with significantly improved long-range identification of enemy ground targets, as well as targeting information to support guided weaponry. The SPI 3-D system employs optics, focal plane arrays, and gimbals combined with a range measurement technique. SPI 3-D technologies are being designed to be compatible with operational ISR systems and may be installed in a joint-service ISR pod (such as LITENING) or a Class IV UAV (Predator, Firescout & Warrior) Multi-spectral Targeting System (MTS) turret. A manned airborne demonstration of SPI-3D components in an ISR pod will be performed to illustrate SPI-3D capabilities. Subsequent to the manned airborne demonstration, transition will be to the U.S. Air Force at the conclusion of Phase III. The program will produce high speed, ultra sensitive photodetectors for systems requiring operation at very low photon counts. This will support long range sensors that can detect highly obscured targets under canopy/camouflage as well as very wide-area search for submerged targets including sea mines and semi-submerged mobile vessels. Video and 3-D imaging through obscurants (VITO) will enable robust under-canopy, high-resolution real-time 3-D video and imagery and for target detection, identification, and tracking based on real-time Volumetric Change Detection (VCD) or Volumetric Moving Target Indication (VMTI). VITO will employ high speed, ultra sensitive photo-detectors and selective range gate processing to permit improved viewing under obscurations. The system will operate at altitudes and standoff ranges compatible with manned and unmanned aircraft. • Spatially Processed Image Detection and Ranging (SPIDAR) is a coherent imaging method that allows one to form a large, effective optical aperture from a set of smaller, lighter telescopes providing for very high-resolution 3-D and 2-D ladar imagery of distant targets with a compact system configuration. This capability is very well suited for long-range engagements from airborne or space-based platforms and could significantly enhance the current synthetic aperture imaging approaches by providing the desired cross-range resolution along the axis perpendicular to the direction of travel. This capability is also applicable on a small scale to provide very-high resolution imagery in a compact and					

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
potentially man-portable configuration for long-range ID. The gain in size, weight and power over more conventional lidar implementations will be assessed and demonstrated. Additionally, suitable missions and platforms for the technology will be identified. SPIDAR technologies will be transitioned to the U.S. Air Force in FY 2013. • The Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND) program will develop and demonstrate a system for collecting and processing IR data operating as a framing sensor. The system will accept long wave infrared and color camera images permitting day/night reconnaissance for real-time target detection and tracking. The resulting sensor and processing system will provide an order of magnitude increase in the combination of area coverage over current systems, and a decrease in time to focus the sensor operator's attention on relevant targets. The TAILWIND system is planned for transition to the U.S. Army by FY 2012. *FY 2009 Accomplishments:* Standoff Precision ID in 3-D (SPI 3-D) - Successfully completed Phase 2 flight demonstrations supporting analysis of performance for next phase of the program. - Initiated SPI 3-D Phase 3 development effort in concert with the Air Force Predator System program office development of the MTS turret to ensure SPI-3D compatibility with the MTS. Spatially Processed Image Detection and Ranging (SPIDAR) - Conducted initial assessment of the performance of the current system configurations and systems analysis of long-range, high-resolution imaging applications. - Identified the trade space for considering multi-aperture receivers and illuminators in the system designs. - Developed conceptual system designs to achieve desired system performance. Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND)					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total

- Completed preliminary design of infrared and color sensor package.
- Developed system design and data flow through to the user.

FY 2010 Plans:

Standoff Precision ID in 3-D (SPI 3-D)
- Complete fabrication of miniaturized components and initiate integration into the demonstration system.
- Develop techniques for target detection, identification, and tracking based on real-time Volumetric Change Detection (VCD) or Volumetric Moving Target Indication (VMTI).
- Perform initial design studies for a Geiger-mode Avalanche Photodiode (GmADP) array-based sensor that provides robust under-canopy, high-resolution real-time 3-D video and imagery using selective range gate processing.

Spatially Processed Image Detection and Ranging (SPIDAR)
- Initiate development of mountain-to-ground multi-aperture system outdoor demonstration to validate system modeling.
- Initiate airborne demonstration system design and key component technology demonstrations.
- Initiate conformal aperture sub-system demonstration development.

Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND)
- Complete detailed design of infrared and color sensor package.
- Develop parallel processing, compression, and image exploitation algorithms.
- Develop passive infrared exploitation technologies.

FY 2011 Base Plans:

Standoff Precision ID in 3-D (SPI 3-D)
- Complete integration of miniaturized components into the demonstration system.

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Conduct airborne demonstration of the Metric Sensing and 3-D imaging on a manned aircraft supporting transition to U.S. Air Force. - Design and implement VCD/VMTI-based target detection, identification, and tracking algorithms in high-performance signal processing hardware architectures. - Hold preliminary design review and initiate fabrication of a prototype sensor for under-canopy 3-D video and imaging. - Develop promising technologies identified for use for air platform to air target identification and location. Spatially Processed Image Detection and Ranging (SPIDAR) - Complete multi-aperture mountain-to-ground demonstration and validate system performance modeling. - Complete airborne system design with validated performance models meeting objective increase in spatial resolution. - Complete supporting critical technology demonstrations. Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND) - Integrate sensor package into target aircraft. - Perform field test of sensor system.					
Wide Area Video Surveillance (U) The Wide Area Video Surveillance program is developing advanced electro-optical and infrared sensor technologies to enable persistent, wide-area, day-night video surveillance. Specific examples of these technologies includes: gigapixel focal plane arrays; advanced digital signal processors for giga-pixel image formation; advanced image processing algorithms for real-time detection, identification, and tracking of elusive and deceptive military targets; and advanced optics, telescopes and gimbals for high-resolution image capture. The Wide Area Video Surveillance program integrates these technologies in proof-of-concept prototypes for demonstration on military platforms including large and	14.750	20.000	16.000	0.000	16.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
small, manned and unmanned aerial vehicles. Wide Area Video Surveillance technologies are planned for transition to the U.S. Air Force. Efforts in this program include: • The Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System (ARGUS-IS) program is developing an airborne sensor system that provides persistent, real-time, high-resolution, wide-area video surveillance. ARGUS-IS will provide the warfighter with a minimum of sixty-five "Predator like" video windows across the field of view. Each video window is electronically steerable and independent of the others. ARGUS-IS can also provide a global moving target indicator for vehicle size objects across the entire field of view. ARGUS-IS is comprised of three major subsystems: (1) a Gigapixel Sensor Subsystem (GSS) which consists of a set of four telescopes and is mounted in a 3-axis stabilized gimbal; (2) an Airborne Processing Subsystem (APS) which takes raw pixels from the GSS and performs all required processing; and (3) a ground processing subsystem which provides the interface to the user and records down-linked imagery. A Memorandum of Agreement (MOA) for the transition of ARGUS-IS from DARPA to the U.S. Air Force has been executed. The transition period is FY 2009 - FY 2010. • The Autonomous Real-time Ground Ubiquitous Surveillance – Infrared (ARGUS-IR) program is developing an airborne sensor system that provides a persistent, real-time, high-resolution, wide-area night video surveillance capability. ARGUS-IR uses an advanced infrared (IR) focal plane array (FPA) sensor. The nighttime persistent capability provided by ARGUS-IR combined with the daytime capability provided by ARGUS-IS enables 24-hour day/night surveillance. ARGUS-IR's wide-area, high-update-rate, high-resolution imaging capability will enable detection and tracking of dismounts as well as vehicles. ARGUS-IR will utilize the signal/image processor developed as part of ARGUS-IS, enabling ARGUS-IS and ARGUS-IR to be combined into a common pod. ARGUS-IR must overcome a number of demanding technical challenges beyond those faced by ARGUS-IS. The most significant challenges relate to the IR FPA and size, weight, and power constraints for the IR sensor. Technologies are planned for transition to the U.S. Air Force.					

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B. Accomplishments/Planned Program ($ in Millions)

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FY 2009 Accomplishments: Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System (ARGUS-IS) - Completed the build of the 1.8 gigapixel sensor, airborne processing system, pod, and ground processing. - Integrated sensor, airborne processor, and data link into ARGUS-IS pod. - Completed Phase 2 software development for ground processing and airborne processing systems. - Conducted flight experiments for video windows and video tracking. - Began building a copy of the sensor and airborne processor for U.S. Air Force. - Executed MOA with the U.S. Air Force for flight testing of ARGUS-IS on an MQ-9 Reaper unmanned air vehicle. *FY 2010 Plans:* Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System (ARGUS-IS) - Complete build and delivery of sensor and airborne processing systems for U.S. Air Force. - Integrate sensor and airborne processing systems into a compatible pod. - Integrate ARGUS-IS pod with target platform. - Conduct flight tests that will validate the video windows and video tracking functionality. Autonomous Real-time Ground Ubiquitous Surveillance – Infrared (ARGUS-IR) - Develop prototype IR FPA. - Develop packaging approach appropriate for the target gimbal. - Begin development of optics for IR sensor. *FY 2011 Base Plans:* Autonomous Real-time Ground Ubiquitous Surveillance – Infrared (ARGUS-IR) - Build the IR FPAs. - Complete development and build of optics for IR Sensor. - Integrate IR sensor into gimbal.					

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Large Area Coverage Search-while-Track and Engage (LACOSTE)	12.150	12.460	4.110	0.000	4.110

(U) The Large Area Coverage Search-while-Track and Engage (LACOSTE) program enables a persistent, tactical-grade ground moving target indicator (GMTI) capability in dense urban areas. Wide-area continuous tracking of moving vehicles requires very small coverage gaps, small resolution cells, and target separation and identification features. The ideal sensor has the area coverage rates of GMTI radar and the resolution/identification capabilities of an electro-optical infrared system. The LACOSTE program will provide wide area surveillance, simultaneous tracking, and target engagement with electro-optical and infrared sensors for tactical GMTI operations. The program is developing a sensor with a very wide field of regard (90 degree cone angle), and a wide instantaneous field of view (FOV) that is rapidly scanned in a search-while-track mode, tracking up to 10,000 targets in an urban area. Additionally, the LACOSTE sensor will provide next-generation precision tracking to enable engagement on a large number of (approximately 100) targets in dense urban areas within that same field of regard with minimal penalty on the search-mode area coverage rate. The program is also developing a rapid “zoom” capability for target identification that enables feature-aided tracking through dense target environments, plus sufficient target identification for separating like-targets when back-tracking a particular target via the historical track data. The LACOSTE technology is planned for transition to the U.S. Air Force and the U.S. Army at the conclusion of the program.

FY 2009 Accomplishments:
- Completed scaled integration of core system technologies.
- Developed and tested computational imaging and tracking algorithms.

FY 2010 Plans:
- Manufacture and test full-scale components.
- Perform system integration and laboratory testing.
- Demonstrate performance (sensitivity, resolution, and tracking) via tower testing.

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B. Accomplishments/Planned Program ($ in Millions)

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FY 2011 Base Plans: - Conduct helicopter demonstration of sensitivity, resolution, and tracking.					
Sensor Tape* *Previously part of Soldier-borne Sensor Technology. (U) The Sensor Tape program will develop and demonstrate a low-cost, one-time-use, low-power, band-aid size, adhesive-applied blast dosimeter that records accumulative blast effects for integration into combat medical care. Significant technical obstacles that must be overcome include achieving adequate switching frequencies, packaging, print-on ink technologies and production costs. Sensor Tape is planned for transition to the Air Force and Army. *FY 2009 Accomplishments:* - Demonstrated proposed sensors and communications capability in controlled laboratory experiments. - Integrated modules into a complete first generation prototype blast dosimeter. - Developed jet-printing processes required for printed sensors, printed electronics and printed memory components. - Developed printed pressure, acceleration, light and acoustic sensors. - Developed proposed sensors and communications capability in controlled laboratory experiments. *FY 2010 Plans:* - Demonstrate web-printing process for sensors, printed electronics and memory components. - Fabricate prototype sensor tapes. - Demonstrate sensor tape performance in field test.	2.046	2.282	0.000	0.000	0.000
Super-Resolution Vision System (SRVS)*	9.482	8.894	11.917	0.000	11.917

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B. Accomplishments/Planned Program ($ in Millions)

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*Previously part of Ground Targeting Sensors. (U) The Super-Resolution Vision System (SRVS) program will develop and build a field prototype soldier-portable optical system that will demonstrate improved recognition and identification range over existing systems. The key technical innovation is exploitation of atmospheric turbulence-generated micro-lensing phenomena to generate images that are superior to diffraction-limited images. A variation of lenses approach, to include adaptive polymer lenses, will also be investigated. SRVS will facilitate new operational and tactical opportunities for land forces. Through enhanced resolution imaging, SRVS will (1) extend target recognition and identification to decisively longer distances; (2) overcome atmospheric turbulence, which now limits the ability of high-resolution optics; and (3) increase target identification confidence to reduce fratricide and/or collateral damage. It will culminate in a field demonstration of a prototype. (U) Additionally, the program will investigate the ability to overcome field of view (FOV) and depth of field (DOF) limitations of conventional optical systems such as those encountered in macro photography by obviating the need for steering or focusing of the optical system through the use of conventional lenses. Recent advances in laser systems, digital imagers, and novel image processing algorithms will be leveraged. It is expected that combining this approach with active 3D laser radar systems will result in the reduction of the overall size, weight and power of imaging systems while providing high-resolution detail at several ranges for target identification purposes. Technology developed under this program will transition to Special Operations Forces. *FY 2009 Accomplishments:* - Conducted demonstration and testing of prototype systems. - Modified design based on experiments and testing to support transition. *FY 2010 Plans:* - Conduct conceptual studies to identify possible lens variations, including adaptive polymer lenses.					

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- Commence fabrication and testing of soldier portable prototype. - Conduct field testing of system performance. - Identify system designs for several compact, high-resolution 3D imaging systems. - Initiate development of critical hardware subsystems for high-resolution 3D imaging systems. *FY 2011 Base Plans:* - Complete development of critical hardware subsystems for high-resolution 3D imaging systems. - Develop advanced image processing algorithms for high-resolution 3D imaging systems. - Commence integration of subsystems for laboratory demonstration of high-resolution 3D imaging capability.					
Short Wave Infrared through Fog and Clouds (SWIF)* *Previously part of Ground Targeting Sensors. (U) The Short Wave Infrared through Fog and Clouds (SWIF) program will develop and demonstrate advanced signal processing and optical imaging technology to allow detection of collision and grounding threats in fog and clouds at useful ranges (day or night), which substantially degrade performance in precision handling operations. Humans are able to operate successfully with sensor assistance, but situational awareness significantly degrades. Successful development of this technology will restore this situational awareness to tactically relevant distance and time scales. Significant technical obstacles that must be overcome include development of an ultra-short pulse laser with sufficient bandwidth and fast enough pulse rise time to create transient-like propagation characteristics in an aerosol cloud, distributed active sources, and advanced filtering techniques. Technologies are planned for transition to the U.S. military. *FY 2009 Accomplishments:* - Conducted modeling and simulation to optimize system range and resolution.	8.781	7.562	0.000	0.000	0.000

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- Conducted experiments under various scattering and absorption conditions to characterize optical link budget. - Developed distributed active obscurant technologies. - Packaged and tested distributed obscurant. *FY 2010 Plans:* - Manufacture test articles. - Distribute obscurant chamber testing and system validation.					
Precision Electronic Warfare (PreEW) (U) The Precision Electronic Warfare (PreEW) program will develop a system to enable highly precise communications jamming. This program will develop and demonstrate robust, low cost, small size, weight and power (SWAP) distributed electronic warfare (EW) platforms to allow the warfighter to disrupt and impede an adversary's communication network. The PreEW program uses an array of nodes that have synchronized clocks to enable the signal from each node to be aligned so that the carrier and phase are focused on the desired location. The effect will be to place the desired energy on the specific target area while not affecting the non-target area. The node is planned to contain localization, network, synchronization and jamming processing and communication in a low-cost, easily deployable package. Key technology challenges include oscillator synchronization, accurate pointing, and energy focusing to impact quality of service of intended target. The PreEW program is planned for transition to the Services in FY 2013. *FY 2010 Plans:* - Design and develop precision clock synchronization techniques for evaluation and selection for static scenarios. - Design beamforming and inter-mode communication architecture. - Experiment with brassboard design to validate ability for small SWAP.	0.000	10.000	14.000	0.000	14.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Perform experiments to validate clock synchronization, precision pointing, and precision jamming capabilities. *FY 2011 Base Plans:* - Design prototype nodes for demonstration purposes. - Conduct initial test using pole mounted payloads.					
Transparent Earth	0.000	0.000	4.000	0.000	4.000
(U) The goal of the Transparent Earth program is to determine the physical, chemical, and dynamic properties of the earth down to 5 km depth, including natural or man-made structures at militarily-relevant spatial scales. The program will focus on two key challenges: the first is to develop a common data model for, or mathematical description of, a three-dimensional section of the earth, to enable aggregation of disparate measurements. The second challenge is to take advantage of emerging sensors and natural indicators of subsurface activity and combine these (along with existing sources) with new algorithms/mathematics (based on algorithm developments under the Airborne Tomography using Active Electromagnetics (ATAEM) program in Project SEN-01) to estimate physical/chemical properties for volumetric elements throughout the earth. Success in these two challenges will lead to the integration of the volumetric elements into a global three-dimensional picture of the earth's subsurface with variable spatial, temporal, and information resolution, allowing changes at local scales to propagate through both physical models and proximity rules to update the global picture. Transparent Earth technology is anticipated to transition to the Army, Air Force, and SOCOM, as well as mapping/intelligence organizations such as NGA and DIA in 2015. *FY 2011 Base Plans:* - Identify and develop promising approaches for the development of new mathematical descriptions of local sections of the underground for common earth-sensing measurements. - Identify and demonstrate feasibility of novel sensors and new mathematics to allow integration of disparate measurement scales.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603767E: *SENSOR TECHNOLOGY*	**PROJECT** SEN-02: *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Precision Inertial Navigation Systems High Dynamic Range Atom System (PINS HiDRA)	0.000	0.000	6.135	0.000	6.135
(U) Precision Inertial Navigation Systems High Dynamic Range Atom System (PINS HiDRA) will develop an integrated atom-based navigation system suitable for use on a wide range of military platforms. The program will build on the work of the Precision Inertial Navigation Systems (PINS) program (funded in PE 0603768E, Project GT-01) to dramatically increase the dynamic range of the sensors, thereby enabling operation on aircraft and missiles. Extensive system integration and miniaturization will reduce system size, weight, and power, while increasing navigation performance as measured against currently fielded aircraft inertial navigation systems. Key technology challenges include high brightness atom sources, innovative atom interferometer measurement schemes that function in high dynamic environments, and high g-tolerant laser stabilization schemes. The PINS HiDRA program will focus on transition to the Services in FY 2014. *FY 2011 Base Plans:* - Design system microcontroller and compact laser and optomechanics frame. - Develop computer models for atom sensor operation under high dynamic input and predict navigation performance under relevant sensor configuration. - Validate sub-system technology selections and incorporate into full six degree-of-freedom inertial sensor design.					
Persistent Operations Surface Surveillance and Engagement (POSSE)*	19.178	0.000	0.000	0.000	0.000
*Previously part of Persistent Exploitation. (U) The Persistent Operations Surface Surveillance and Engagement (POSSE) program is developing the capability to integrate sensor input from multiple modalities to find indications of insurgent activities. Combined with dynamically updated information from soldiers on the ground, POSSE will enable near-real-time generation of the evidence necessary for further investigation or interdiction. POSSE experiments are conducted at the National Training Center (NTC) with realistic role players emulating					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
typical residential, commercial and light industrial activity. Within this environment, insurgent activity is simulated by qualified experts using the latest and most complete intelligence available. Measurements include precision collections of insurgent activities, as well as the realistic surrounding background clutter of typical civilian activity. Results will inform future experiments, lead to specifications for future sensor design, and provide insights into how to integrate other narrow and wide area sensors into an integrated approach to countering insurgencies. Transition is planned for U.S. Army Intelligence and Security Command. The concepts and technology developed in this program will continue in PE 0603767E, Project SEN-03. *FY 2009 Accomplishments:* - Conducted two chemical detection experiments to characterize the chemical environment and quantify signatures associated with the bomb making enterprise within this environment. - Continued data analysis and algorithm development to correlate chemical signatures over time and space to help reveal the bomb maker network.					
Target Identification Technology (U) The Target Identification Technology thrust develops semiautomatic methods to identify targets from sensors operating in all spectral bands. Its objective is to detect, characterize, and identify military threats, and to assess the environment around them. Data sources include national, theater, and organic sensors. Exploiting the acoustic emissions of potential targets is of interest because acoustics has the advantage of not requiring an unobstructed line of sight between the emitter and sensor, and under certain circumstances sound may propagate great distances. Critical performance metrics are timeliness, accuracy, error rates, and interpretation workload. The thrust addresses the challenges of target identification, acquisition and tracking under restrictive rules of engagement. The technologies will apply advanced signal processing and machine vision to leverage advances in sensor capabilities. The concepts and technology developed in this program will continue in PE 0603767E, Project SEN-03.	9.000	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
• The All-Source Target Characterization program developed a collection and measurement capability to characterize new targets as they emerge on the battlefield. This effort developed tools to permit rapid user interaction with imagery, sensor data, and processing results and provided real-time feedback to operators indicating key target features and other discriminates. This initiative also evaluated robust target cueing and identification over large classes of targets within a computational form factor appropriate for insertion into strike aircraft and unmanned aerial vehicles. The technology provides tools to process and disseminate target signatures to the field in usable formats for direct insertion into operational systems. • The Small Unmanned Aerial Vehicle Detection System (SUDS) program develops techniques to detect, track, and provide discrimination between friend and foe against small UAVs that are easily built, inexpensive, easy to operate, and offer the asymmetric adversary an ability to reach into U.S. defended locations causing potentially large amounts of damage. It includes antenna and signal processing techniques to passively detect small air targets using radar, video, acoustic, and radio-frequency sensors; to correlate those data with known objects (e.g., civilian aircraft); to analyze the motion of any uncorrelated data; and to rapidly task narrow-field-of-view sensors to collect more-detailed data. It will transition to the Services to meet both static force protection needs and tactical air defense operations. *FY 2009 Accomplishments:* All-Source Target Characterization - Evaluated performance in field exercises and demonstrations. Small Unmanned Aerial Vehicle Detection System (SUDS) - Developed algorithms to identify and classify targets and objects of interest. - Performed tests against UAV and radio controlled (RC) aircraft of known and unknown characteristics to demonstrate the system's ability to improve target detection and classification. - Performed data collection to determine acoustic features/signatures/characteristics. - Applied results to physics models of aircraft and propulsion systems.					

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
SandBlaster*	2.000	1.000	1.000	0.000	1.000
Crosswind Sensor System for Snipers (C-WINS)* and Dynamic Image Gunsight Optics (DInGO)	6.951	6.000	7.000	0.000	7.000

*Previously part of Ground Targeting Sensors.

(U) The SandBlaster program developed a helicopter pilot performance enhancement system for landing in degraded visual environments such as Iraq and Afghanistan dust clouds. Sandblaster addressed this important operational challenge in a Blackhawk platform environment, in four distinct areas: (1) Advanced flight controls which enable the helicopter to auto-land at a pilot-selected landing point; (2) See-through sensing based on a forward-looking three dimensional W-band radar, which enables the pilot to see through the dust and select a safe landing point; (3) A powerful fusion engine which combines map and obstacle database knowledge with real-time radar data to construct a full current assessment of landing zone hazards; and (4) An enhanced synthetic vision display to present this evolving real-time landing zone information to the pilot in the most useful manner, combined with all necessary aircraft-state symbology needed to complete a safe landing. The technology developed under this program transitioned to U.S. Special Operations Command (USSOCOM), the U.S. Air Force and the U.S. Army.

FY 2009 Accomplishments:
- Completed Sandblaster system performance testing and demonstrated capabilities in the JUH-60A Blackhawk helicopter.
- Transitioned Sandblaster technology to the services.

FY 2010 Plans:
- Commence design of a lighter weight system for use on DoD operational helicopters.

FY 2011 Base Plans:
- Complete design of a lighter weight system for use on DoD operational helicopters.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
*Previously part of Soldier-borne Sensor Technology. (U) The Crosswind Sensor System for Snipers (C-WINS) program provided optical techniques to correct for crosswinds on ballistic objects. The C-WINS program developed a novel weapon mounted optical correction sighting system for various rifles and machine guns. An eye safe laser and a high speed camera record motion of eddies in the atmosphere to measure the wind profile that will be used to provide ballistic correction. The system provides offset corrections to the shooter for compensating the aim point affected by the crosswind. Key parameters of interest are: a) bullet hit points less than the target size at any range up to weapons effective range; b) down range profiling up to weapons effective range; c) ranging accuracy sufficient to provide elevation correction; d) automatic ballistic correction; e) day/night operation; and f) no setup or calibration. Additional capabilities could include: increased effective ranges for a wide range of weapons; eye safe ranging; increased ID range during day and night; and shimmer compensation. This program transitioned to the U.S. Army and Marines. (U) Leveraging technologies developed under the Crosswind Sensor System for Snipers (C-WINS) program, the Dynamic Image Gunsight Optics (DInGO) program will develop an optical scope that enables a soldier, with minimal training, to shoot a firearm with marksman accuracy. The ability to engage targets at range with a conventional firearm is currently limited by user training rather than the accuracy of the weapon. The technology developed under this program line will enhance a soldier's ability to observe and engage targets at range as well as enhance the capability for close quarters combat. Technical achievements under other programs in this PE/Project provide the basis for radically new approaches to optical scopes, dynamic imaging systems, and low-power video analytics. By extending the capability of combat optics, DInGO enables a soldier to operate at the limit of the system performance with reduced training requirements. Transition to the Army in 2013 is anticipated. *FY 2009 Accomplishments:* Crosswind Sensor System for Snipers (C-WINS) - Developed transition and manufacturing plans.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Developed and built one prototype system and integrated and tested system in the lab and field. - Transitioned to the Army and Marine Corps. *FY 2010 Plans:* Dynamic Image Gunsight Optics (DInGO) - Perform major system design trades. - Develop a system design for a combat-rifle scope that can be used for close quarters combat as well as to engage targets at distance. - Validate key technology components. *FY 2011 Base Plans:* Dynamic Image Gunsight Optics (DInGO) - Fabricate portable brassboard prototype systems.					
Laser Geospatial Referencing (LGR)* *Previously part of Soldier-borne Sensor Technology. (U) The Laser Geospatial Referencing (LGR) system investigated technologies to allow ground troops to designate targets for engagement by air forces where the pilot or UAV operator can see the designated spots within the field of view of their visible or forward looking infrared system. The LGR concept looked to provide nearly instantaneous target location, identification and designation capabilities to weapon platforms supporting urban or other ground operations. The LGR concept enables these assets to be immediately directed by dismounted soldiers. Data developed in this program transitioned to the U.S. Army and Marine ground forces and U.S. Air Force. *FY 2009 Accomplishments:* - Completed initial feasibility study to determine concept of operations (CONOPS) and design requirements.	2.000	0.000	0.000	0.000	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Assessed technology development required to meet objectives and developed program plan. - Initiated supporting focal plane array technology development for LGR.					
Foliage Penetration Reconnaissance Surveillance Tracking and Engagement Radar (FORESTER) (U) The Foliage Penetration Reconnaissance Surveillance Tracking and Engagement Radar (FORESTER) program developed an ultra high frequency (UHF) ground moving target indicator (GMTI) radar that can detect dismounts and vehicles moving under dense foliage. In the first phase of the program, the FORESTER was installed on a Black Hawk and flown in a series of successful demonstrations in the U.S. and OCONUS. In the second phase of the program, FORESTER was successfully flown on the A160, a revolutionary high-altitude long-endurance unmanned helicopter developed by DARPA and the U.S. Army. FORESTER development concluded with radar field experiments conducted jointly with operational users to refine and optimize FORESTER radar performance and concepts of operation. *FY 2009 Accomplishments:* - Conducted radar field experiments and then, based on the results, refined and optimized FORESTER radar performance and concepts of operation. - Transitioning FORESTER to the operational user.	5.500	0.000	0.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	118.880	99.486	82.541	0.000	82.541

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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
SEN-03: *EXPLOITATION SYSTEMS*	0.000	33.455	51.807	0.000	51.807	68.148	61.407	59.407	56.013	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Exploitation Systems project develops algorithms, software, and information processing systems to extract information from massive intelligence, surveillance, and reconnaissance (ISR) datasets. In particular, it develops new technologies for detection and discrimination of targets from clutter, classification and fingerprinting of high value targets, localization and tracking over wide areas, and threat network identification and analysis. Efforts will focus on difficult ISR environments, for example (a) urban environments with extensive building obscuration, large volumes of civilian traffic, and feature-rich terrain, (b) mountain environments with highly variable terrain elevation, complex local and regional threat networks, and predominantly dismounted adversaries, and (c) jungle environments with targets under heavy canopy, animal and other sources of clutter masking human activity, and widely dispersed threat activities. The resulting technology will enable operators to more effectively use ISR data in the execution of a wide variety of wide area search, border and road monitoring, high value target tracking, overwatch, and other missions.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Persistent Operations Surface Surveillance and Engagement (POSSE)* *Formerly Persistent Exploitation. (U) The Persistent Operations Surface Surveillance and Engagement (POSSE) program (previously funded in PE 0603767E, Project SEN-02) is developing the capability to integrate sensor input from multiple modalities to find indications of insurgent activities. Combined with dynamically updated information from soldiers on the ground, POSSE will enable near-real-time generation of the evidence necessary for further investigation or interdiction. POSSE experiments are conducted at the National Training Center (NTC) with realistic role players emulating typical residential, commercial and light industrial activity. Within this environment, insurgent activity is simulated by qualified experts using the latest and most complete intelligence available. Measurements include precision collections of	0.000	11.955	13.000	0.000	13.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
insurgent activities, as well as the realistic surrounding background clutter of typical civilian activity. Results will inform future experiments, lead to specifications for future sensor design, and provide insights into how to integrate other narrow and wide area sensors into an integrated approach to countering insurgencies. Transition is planned for U.S. Army Intelligence and Security Command. *FY 2010 Plans:* - Conclude the Chemical Detection Experiment series, analyze results, and provide data to inform new sensor designs. - Examine the feasibility of new sensor designs. *FY 2011 Base Plans:* - Design and develop new sensors specific to close-in insurgent activity detection. - Demonstrate new insurgent activity detection techniques in field exercises at the National Training Center.					
Foliage Penetrating Radar Planning and Exploitation (U) The Foliage Penetrating Radar Planning and Exploitation program will complete final Forester FOPEN radar demonstrations (previously budgeted in PE0603767E, Project SEN-02) and provide further exploitation capabilities to find dismounted targets in densely forested terrain. Current foliage penetrating radar systems provide an important capability for detecting dismount targets under foliage, but the systems also detect animals, moving water, blowing trees, and other scene clutter moving under or in the foliage that makes situation assessment manpower and radar resource intensive. Further, Doppler signature data that experiments indicate may enable improved automated discrimination of dismount targets from other detections is not currently exploited. Finally, no planning tools are available for optimizing and dynamically replanning collection assets to improve imaging geometries and detectability. This program will provide capabilities to address these issues by exploiting Doppler signature data, automating temporal processing approaches currently used, and automating terrain, weather, and on-line exploitation data to enable planning and dynamic replanning. The result will	0.000	5.500	8.500	0.000	8.500

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
be significantly improved capability for finding and localizing targets under foliage. The program will transition to SOUTHCOM and SOCOM. *FY 2010 Plans:* - Formulate algorithms for mitigating detections in radar systems due to non-living objects in motion and confusion between humans and animals. *FY 2011 Base Plans:* - Evaluate and optimize algorithms for mitigating detections in radar systems due to non-living objects in motion and confusion between humans and animals and develop planning capabilities. - Begin development of planning and dynamic re-planning capabilities.					
Multi-Sensor Exploitation (U) The Multi-Sensor Exploitation program continues efforts previously budgeted in PE 0603767E, Project SEN-02 and will provide multi-sensor exploitation capabilities enabling mission overwatch, border surveillance, high value target tracking, and threat network detection using mixes of imaging, radar, signals, human intelligence, and other sources. Key challenges in the first two missions include real-time and wide area dismount and vehicle target detection, discrimination, tracking, and pattern of life analysis. Key challenges in the third mission include tracking through periods of obscuration and confusion in environments in which existing sensors and methods are not able to provide high quality signature data. Key challenges in the fourth mission include discriminating threats from large volumes of civilian clutter and determining the behavior patterns of and relationships between those threats. The Multi-sensor Exploitation program will develop new target tracking methods for wide area motion imaging sensors enabling long duration tracking of vehicles and dismounts through the development of new target dynamic modeling methods, new processing methods tailored to dismounts, and new methods for signature aided tracking. The program will develop new methods for automatically correlating different sources of information to identify threats, estimate threat networks, and analyze behavioral patterns. The program will include a focus on integrated human and machine processing to	0.000	8.000	17.900	0.000	17.900

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
better take advantage of the strengths of each. Technologies are planned for transition to the Air Force, Army, SOCOM, and Intelligence agencies. *FY 2010 Plans:* - Create new methods for tracking targets in urban environments leveraging dynamic models motivated by traffic flow theory. - Develop architectures for enabling combined use of multiple sensors, including motion imagery, signals intelligence, and other sources, for threat detection and threat network identification. *FY 2011 Base Plans:* - Evaluate and optimize techniques and software for tracking targets in dense target environments. - Develop and test algorithms for combining multiple sensors for threat detection and network identification. - Demonstrate integrated machine-human processing. - Design automated algorithms for high value target tracking in urban environments.					
Target Identification (U) The Target Identification program continues efforts previously budgeted in PE 0603767E, Project SEN-02 to develop methods to detect, characterize, and identify targets from both electromagnetic and acoustic sensors. Data sources include national, theater, and organic sensors. Exploiting the acoustic emissions of potential targets is of interest because acoustics do not require an unobstructed line of sight between the emitter and sensor, and under certain circumstances sound may propagate great distances. Critical performance metrics are timeliness, accuracy, error rates, and interpretation workload. The program addresses the challenges of target identification, acquisition, tracking and denial in difficult environments. The technologies will apply advanced signal processing and control to leverage advances in sensor capabilities. Transition is planned to the Navy.	0.000	8.000	12.407	0.000	12.407

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: - Design and analyze performance of new sensing approaches for target detection and perform limited field testing. - Develop concepts of employment and an overall system architecture, and validate with potential transition customers. *FY 2011 Base Plans:* - Develop sensors, mount on surrogate platforms, and field test in realistic operating environments. - Validate concepts of employment, and test overall system via modeling and simulation.					
Accomplishments/Planned Programs Subtotals	0.000	33.455	51.807	0.000	51.807

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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency			**DATE:** February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
SEN-CLS: *Classified*	0.000	39.306	28.398	0.000	28.398	46.820	38.282	28.964	38.989	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) in the Special Access Program Annual Report to Congress.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Classified DARPA Program This project funds Classified DARPA Programs. Details of this submission are classified. *FY 2010 Plans:* Details will be provided under separate cover. *FY 2011 Base Plans:* Details will be provided under separate cover.	0.000	39.306	28.398	0.000	28.398
Accomplishments/Planned Programs Subtotals	0.000	39.306	28.398	0.000	28.398

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603768E: *GUIDANCE TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	93.720	36.886	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
GT-01: *GUIDANCE TECHNOLOGY*	37.704	17.235	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
GT-CLS: *CLASSIFIED*	56.016	19.651	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing system oriented technologies that will improve our ability to navigate weapon systems with more precision and increase the capability to meet current and emerging threats. Consequently, this program element will merge with the Sensors Technology program element in FY 2011. Many of the guidance programs have ended eliminating the need for such a specifically focused program element.

(U) The Guidance Technology project increases the ability of Global Positioning System (GPS) users to operate effectively in the presence of enemy jamming; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems.

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B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	107.979	37.040	0.000	0.000	0.000
Current President's Budget	93.720	36.886	0.000	0.000	0.000
Total Adjustments	-14.259	-0.154	0.000	0.000	0.000
• Congressional General Reductions		-0.154			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	-5.100	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	-6.125	0.000			
• SBIR/STTR Transfer	-3.034	0.000			

Change Summary Explanation

FY 2009

Decrease reflects Section 8042 rescission of the FY 2010 Appropriations Act, Omnibus Reprogramming action for the H1N1 vaccine development and SBIR/STTR transfer offset by internal below threshold reprogramming.

FY 2010

Decrease reflects the Section 8097 Economic Assumption.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	R-1 ITEM NOMENCLATURE PE 0603768E: *GUIDANCE TECHNOLOGY*	PROJECT GT-01: *GUIDANCE TECHNOLOGY*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
GT-01: *GUIDANCE TECHNOLOGY*	37.704	17.235	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) Fire-and-forget stand-off weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: 1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; 2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and 3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. Thrusts are included in this project to improve our ability to navigate when the Global Positioning System (GPS) is jammed or otherwise unavailable; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Multifunctional Electro-Optics for Defense of U.S. Aircraft (MEDUSA)	8.807	5.892	0.000	0.000	0.000
(U) The Multifunction Electro-Optics for Defense of U.S. Aircraft (MEDUSA) program will develop the technologies and systems to give the U.S. air dominance at low altitude and at night. This program will develop the technologies to leap-frog reactive end-game countermeasures and enable increased threat warning times, denial of launch, and put Electro Optical-Infrared (EO-IR) air defense threats at risk in the Near Infrared (NIR), Mid-wave Infrared (MWIR) and Long-wave Infrared (LWIR) regimes. MEDUSA is a three-part technology program that is: 1) conducting phenomenological measurements and develop countermeasures and target classification/identification techniques; 2) developing critical component technologies such as high-power IR laser sources, advanced IR detectors, and fibers for high-power IR transmission; and 3) developing and demonstrating an end-to-end MEDUSA system. The MEDUSA technology is planned for transition to the Air Force and Army at the conclusion of technology development and flight demonstration.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603768E: *GUIDANCE TECHNOLOGY*	**PROJECT** GT-01: *GUIDANCE TECHNOLOGY*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: - Completed testing of 128x128 Near/Mid-Wave Infrared (NMIR) focal plane arrays (FPA) integrated with a low-power, high-speed Read-Out Integrated Circuit (ROIC), demonstrating high-sensitivity in a cryo-cooler package meeting program objectives for proactive infrared countermeasures. - Initiated designs for the 4x larger format NMIR 256x256 arrays needed to provide full coverage against advanced infrared missile threats. - Completed integration of 128x128 Long-wave Infrared (LWIR) detector with a high-speed ROIC, demonstrating high-sensitivity large format heterodyne receiver performance in a mechanical cryo-cooler package. *FY 2010 Plans:* - Complete initial design of large format 256x256 NMIR detector and ROICs supporting proactive IRCM and other applications. - Complete testing of first NMIR detector arrays and ROICs and initiate hybridization. - Complete testing of integrated 128x128 LWIR focal plane arrays to understand the performance of wide field-of-view coherent receivers and determine objectives for next phase of development. - Initiate design and fabrication of low power dissipation, large-format LWIR coherent arrays. - Initiate the development of high-power NMIR and LWIR laser sources to support proactive Infrared Counter Measure (IRCM) system objectives. - Complete testing of first large-format 256x256 NMIR FPAs to guide the final phase of design for these arrays. - Complete final phase of design and initiate fabrication of the large-format 256x256 NMIR FPAs. - Complete fabrication and testing of first phase of large-format LWIR coherent arrays to guide final design and fabrication. - Complete initial demonstration of high-power laser sources needed to support airborne system demonstrations. - Initiate designs for integrated NMIR/LWIR airborne proactive IRCM demonstration.					

Exhibit R-2A, **RDT&E Project Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603768E: *GUIDANCE TECHNOLOGY*	**PROJECT** GT-01: *GUIDANCE TECHNOLOGY*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Robust Surface Navigation (RSN) (U) The Robust Surface Navigation (RSN) program will provide the U.S. warfighter with the ability to navigate effectively when the Global Positioning System (GPS) is unavailable due to hostile action (e.g. jamming) or blockage by structures and foliage. The RSN program will use Signals of Opportunity (SoOP) from a variety of ground, air, and space-based sources, augmented by judiciously placed RF beacons; these will be received on the warfighter's forthcoming software defined radios and use specially tailored algorithms to determine position. The greater strength and diversity of these signals will provide coverage when GPS is denied due to environmental conditions or hostile activity. This is a two-part program: (1) cataloging and assessing potential exploitable signals followed by analysis and performance modeling and hardware-based concept validation, and; (2) designing, testing, and demonstrating a (non-form-fit) prototype receiver(s) and algorithms for geolocation using the SoOP. Beginning in FY 2011, this program will be budgeted in PE 0603767E, Project SEN-01. The RSN technology is planned for transition to the U.S. Special Operations Command (SOCOM) and the U.S. Army with specific elements of the program transitioning to the U.S. Navy and U.S. Air Force. *FY 2009 Accomplishments:* - Performed RSN technical risk mitigation experiments and analysis. - Validated reference station error budget for SoOP characterization and timing. - Completed Critical Design Review for full RSN system. *FY 2010 Plans:* - Develop RSN prototype system and conduct field tests and demonstrations in dense urban environments, including within large buildings and urban canyons. - Demonstrate total system readiness.	7.425	4.000	0.000	0.000	0.000
Sub-Surface Navigation (SsN) (U) Building on technologies developed under the RSN program, the Sub-Surface Navigation (SsN) program will provide the U.S. warfighter with the ability to navigate effectively underground, where	3.140	1.343	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603768E: *GUIDANCE TECHNOLOGY*	**PROJECT** GT-01: *GUIDANCE TECHNOLOGY*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
the Global Positioning System (GPS) is unavailable. SsN will also enable long endurance or covert underground missions where alternative navigation aids like inertial measurement units (IMUs) or inertial navigation units (INUs) are unsuitable. The SsN program will use Signals of Opportunity (SoOP) and will develop specialized low frequency RF beacons and specially tailored algorithms to provide 3-dimensional navigation of personnel and mobile platforms underground. SoOP include global lightning events, which are abundant, propagate over very long distances, and are essentially non-deniable signals. The greater strength and diversity of these signals will provide coverage when GPS is denied due to lack of penetration through the earth. This is a two part program: (1) analysis and performance modeling and hardware-based concept validation of beacon-based signals, and experimental verification that SoOP have propagated (and dispersed) through various geological overburdens and can be correlated with sufficient accuracy to achieve desired geolocation resolution; and (2) designing, testing, and demonstrating a (non-form-fit) prototype receiver(s) and algorithms for geolocation using both beacons and SoOP. The SsN technology is planned for transition to the U.S. Special Operations Command (SOCOM). *FY 2009 Accomplishments:* - Continued design and development of prototype system with improved beacons and receivers. - Developed hardware and software for a blended solution to use when operating the beacon-based in the infrastructure transition zone between improved and unimproved underground environments. - Developed electromagnetic modeling capability to support beacon-based system performance predictions. - Tested functional prototype beacon-based system in an underground environment. *FY 2010 Plans:* - Complete experimental measurements to support next generation, small form-factor beacon antenna design. - Complete transition of SoOP technology to U.S. Special Operations Command (SOCOM).					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603768E: *GUIDANCE TECHNOLOGY*	**PROJECT** GT-01: *GUIDANCE TECHNOLOGY*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Precision Inertial Navigation Systems (PINS) (U) The Precision Inertial Navigation Systems (PINS) program will develop an entirely new class of inertial navigation instruments using atomic inertial force sensors. These sensors utilize the quantum-mechanical wave-like nature of atoms in the atomic analogue of an optical interferometer to provide unprecedented sensitivity to accelerations and rotations. The atomic sensors will further be used to measure the local gravitational field gradient to ensure that instrument alignment is properly maintained throughout vehicle maneuver, thus mitigating gravity-induced navigation errors. Initial program efforts will focus on developing fundamental technology components upon which future systems would be constructed. While originally planned for transition to the Navy at the conclusion of Phase III, program developments indicate opportunities for insertion in multiple Service applications and plans are being revised accordingly. *FY 2009 Accomplishments:* - Completed extensive laboratory testing single degree-of-freedom atom-based inertial measurement unit and single-axis gravity gradiometer and evaluated long-term performance characteristics. - Designed and constructed pre-production prototype for final evaluation by Marine Corps combat swimmers. *FY 2010 Plans:* - Complete study of technical hurdles preventing 200 hour continuous sensor system operation and design system changes to address key items identified. - Devise transition plan for technology insertion consistent with Department of Defense Positioning, Navigation, and Timing roadmap.	6.439	6.000	0.000	0.000	0.000
Navigation-Grade MEMS Inertial Measurement Unit (IMU) (U) The Navigation-Grade MEMS Inertial Measurement Unit (IMU) program developed micro-scale accelerometers and gyros with navigation-grade performance that use only milli-watts of power. The program transcended traditional single mass-spring methods for navigation sensing and explored	11.893	0.000	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603768E: *GUIDANCE TECHNOLOGY*	**PROJECT** GT-01: *GUIDANCE TECHNOLOGY*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
alternative approaches, such as multiple, interconnected mass-spring systems, micro-levitated spinning structures, micro-optical readout mechanisms, atomic interferometric readout mechanisms, and fluidic contortions. This program has transitioned to industrial performers for developing wearable inertial measurement units (IMUs) for dismounted warfighters capable of GPS-denied navigation for lengthy periods; small IMUs for unmanned air and underwater vehicles, and for guidance of small, long-range munitions. *FY 2009 Accomplishments:* - Developed micro-environmental control. - Completed control electronics integration.					
Accomplishments/Planned Programs Subtotals	37.704	17.235	0.000	0.000	0.000

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.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Defense Advanced Research Projects Agency		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603768E: *GUIDANCE TECHNOLOGY*	**PROJECT** GT-CLS: *CLASSIFIED*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
GT-CLS: *CLASSIFIED*	56.016	19.651	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) in the Special Access Program Annual Report to Congress.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Classified DARPA Program This project funds Classified DARPA Programs. Details of this submission are classified. *FY 2009 Accomplishments:* Details will be provided under separate cover. *FY 2010 Plans:* Details will be provided under separate cover.	56.016	19.651	0.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	56.016	19.651	0.000	0.000	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605502E: *SMALL BUSINESS INNOVATIVE RESEARCH*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	78.877	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
SB-01: *SMALL BUSINESS INNOVATIVE RESEARCH*	78.877	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

In accordance with Public Law No: 111-43 (Small Business Reauthorization Act of 2009) and Public Law 107-50 (Small Business Technology Transfer Program Reauthorization Act of 2001), the DARPA Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities.

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	0.000	0.000	0.000	0.000	0.000
Current President's Budget	78.877	0.000	0.000	0.000	0.000
Total Adjustments	78.877	0.000	0.000	0.000	0.000
• Congressional General Reductions		0.000			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	78.877	0.000			

Change Summary Explanation

FY 2009
Increase reflects the SBIR/STTR transfer.

C. Accomplishments/Planned Program ($ in Millions)

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605502E: *SMALL BUSINESS INNOVATIVE RESEARCH*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Small Business Innovative Research In accordance with Public Law No: 111-43 (Small Business Reauthorization Act of 2009) and Public Law 107-50 (Small Business Technology Transfer Program Reauthorization Act of 2001), the DARPA Small Business Innovative Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to bridge the gap between fundamental discoveries and the provision of new military capabilities. *FY 2009 Accomplishments:* The DARPA SBIR and STTR programs were executed within OSD guidelines.	78.877	0.000	0.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	78.877	0.000	0.000	0.000	0.000

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010

APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605897E: *DARPA AGENCY RELOCATION*

COST ($ in Millions)	**FY 2009 Actual**	**FY 2010 Estimate**	**FY 2011 Base Estimate**	**FY 2011 OCO Estimate**	**FY 2011 Total Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
Total Program Element	27.924	44.812	11.000	0.000	11.000	0.000	0.000	0.000	0.000	Continuing	Continuing
AR-02: *DARPA AGENCY RELOCATION*	27.924	44.812	11.000	0.000	11.000	0.000	0.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This Program Element is budgeted in the Management Support Budget Activity to meet building relocation support cost requirements for the Defense Advanced Research Projects Agency (DARPA). The move to a new facility is required by the Department of Defense Unified Facilities Criteria (UFC) and Anti-terrorism/Force Protection Requirements Regulation (UFC 4-010-01 dtd 8 Oct 2003, as amended 22 Jan 2007). The regulation lists force protection standards and is mandatory for facilities leased for DoD use. The regulation applies to all new leases executed on or after 1 Oct 2005 and to renewal or extension of any existing lease on or after 1 Oct 2009. DARPA's existing leased facility does not meet the UFC standards and the lease expires 30 Jul 2010. This Program Element will fund all expenses associated with planning and movement of the Agency to its new location. Initial costs will include design and trade studies, costs associated with implementing force protection standards, floor plan layout and planning activities leading up to the move. Further, it will fund outfitting of the selected property with the force protection standards, infrastructure, equipment, and furniture required for the DARPA staff and completion of the move in the 2011-2012 timeframe.

B. Program Change Summary ($ in Millions)

	FY 2009	**FY 2010**	**FY 2011 Base**	**FY 2011 OCO**	**FY 2011 Total**
Previous President's Budget	27.924	45.000	0.000	0.000	0.000
Current President's Budget	27.924	44.812	11.000	0.000	11.000
Total Adjustments	0.000	-0.188	11.000	0.000	11.000
• Congressional General Reductions		-0.188			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• TotalOtherAdjustments	0.000	0.000	11.000	0.000	11.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605897E: *DARPA AGENCY RELOCATION*

Change Summary Explanation

FY 2010
Decrease reflects the Section 8097 Economic Assumption.
FY 2011
Not Applicable

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
DARPA Agency Relocation	27.924	44.812	11.000	0.000	11.000
DARPA Agency Relocation *FY 2009 Accomplishments:* - Lease signed July 2009. - Reviewed core and shell implementation of force protection standards such as blast proofing. - Initialized design of tenant build out of commercial facility. *FY 2010 Plans:* - Complete design of tenant build out. - Initiate construction of tenant build out to include: - Unclassified office space, Sensitive Compartmented Information Facilities (SCIFs), and Conference center. - Wiring closets; building security system; unclassified and classified cabling; and all associated activities to prepare the building for occupancy. *FY 2011 Base Plans:* - Complete tenant build out. - Outfit offices, conference rooms, and conference center with IT equipment. - Move services to transition from existing to new facility. - Complete restoration of current facility in accordance with lease requirements.					

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605897E: *DARPA AGENCY RELOCATION*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Accomplishments/Planned Programs Subtotals	27.924	44.812	11.000	0.000	11.000

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605898E: *MANAGEMENT HQ - R&D*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	53.569	54.842	56.257	0.000	56.257	57.848	59.582	61.370	63.212	Continuing	Continuing
MH-01: *MANAGEMENT HQ - R&D*	53.569	54.842	56.257	0.000	56.257	57.848	59.582	61.370	63.212	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical security, travel, supplies and equipment, communications, printing and reproduction.

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	48.568	51.055	0.000	0.000	0.000
Current President's Budget	53.569	54.842	56.257	0.000	56.257
Total Adjustments	5.001	3.787	56.257	0.000	56.257
• Congressional General Reductions		-0.213			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	5.001	4.000			
• SBIR/STTR Transfer	0.000	0.000			
• TotalOtherAdjustments	0.000	0.000	56.257	0.000	56.257

Change Summary Explanation

FY 2009

Increase reflects a below threshold reprogramming action to cover salaries and bonuses.

FY 2010

Increase reflects the internal below threshold reprogramming action to cover salaries and bonuses offset by the Section 8097 Economic Assumption.

FY 2011

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605898E: *MANAGEMENT HQ - R&D*

Not Applicable

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Management Headquarters	53.569	54.842	56.257	0.000	56.257

Management Headquarters

FY 2009 Accomplishments:
- Funded civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.
- Funded travel, rent and other infrastructure support costs.
- Funded security costs to continue access controls, uniformed guards, and building security requirements.
- Funded CFO Act compliance costs.
- Funded DARPA share of DoD Acquisition Workforce Fund.

FY 2010 Plans:
- Fund civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.
- Fund travel, rent and other infrastructure support costs.
- Fund security costs to continue access controls, uniformed guards, and building security requirements.
- Fund CFO Act compliance costs.
- Fund DARPA share of DoD Acquisition Workforce Fund.

FY 2011 Base Plans:
- Fund civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs.
- Fund travel, rent and other infrastructure support costs.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605898E: *MANAGEMENT HQ - R&D*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Fund security costs to continue access controls, uniformed guards, and building security requirements. - Fund CFO Act compliance costs. - Fund DARPA share of DoD Acquisition Workforce Fund.					
Accomplishments/Planned Programs Subtotals	53.569	54.842	56.257	0.000	56.257

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency	**DATE:** February 2010

APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0305103E: *CYBER SECURITY INITIATIVE*

COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	49.865	49.791	10.000	0.000	10.000	10.000	10.000	0.000	0.000	Continuing	Continuing
CYB-01: *CYBER SECURITY INITIATIVE*	49.865	49.791	10.000	0.000	10.000	10.000	10.000	0.000	0.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The National Cyber Security Initiative will foster a revolution in the Nation’s ability to protect and defend its cyber operations. DARPA’s responsibility as part of the overall Cyber Security Initiative (CSI) is to create a cyber test range that will become a National resource for testing the resiliency of cyber programs in the face of hostile action. The Cyber Range will be capable of supporting multiple, simultaneous, segmented tests in realistically configured or simulated testbed environments.

B. Program Change Summary ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	49.865	50.000	0.000	0.000	0.000
Current President's Budget	49.865	49.791	10.000	0.000	10.000
Total Adjustments	0.000	-0.209	10.000	0.000	10.000
• Congressional General Reductions		-0.209			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds		0.000			
• Congressional Directed Transfers		0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• TotalOtherAdjustments	0.000	0.000	10.000	0.000	10.000

Change Summary Explanation

FY 2010
Decrease reflects the Section 8097 Economic Assumption.
FY 2011
Not Applicable

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Defense Advanced Research Projects Agency	DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0305103E: *CYBER SECURITY INITIATIVE*

C. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Cyber Security Initiative	49.865	49.791	10.000	0.000	10.000
Accomplishments/Planned Programs Subtotals	49.865	49.791	10.000	0.000	10.000

(U) The goal of the Cyber Security Initiative is to revolutionize the Nation's ability to conduct cyber operations by developing a persistent and cost effective cyber testing environment. The National Cyber Range (NCR) will produce qualitative and quantitative assessments of cyber security research and development programs through a safe, fully-automated and instrumented environment. The range will replicate complex, large-scale, heterogeneous networks and users of current and future systems and operations. It will revolutionize cyber testing by enabling multiple, independent, simultaneous experiments on the same infrastructure to facilitate realistic testing of global scale research, and develop and revolutionize the state-of-the-art in cyber testing in order to facilitate rapid transition of research programs to operations.

FY 2009 Accomplishments:
- Developed detailed engineering plans, system engineering plans, and concepts of operations.
- Refined the specifications leading to prototype development.
- Completed operational partner transition study.

FY 2010 Plans:
- Develop prototype range and demonstration technologies.
- Develop key technologies relevant to cyber testing.
- Complete NCR prototype development and complete planning for full-scale system development.

FY 2011 Base Plans:
- Complete transition of program to a transition partner.
- Continue development of high-risk, high payoff cyber testing technologies.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2011 Defense Advanced Research Projects Agency		**DATE:** February 2010
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0305103E: *CYBER SECURITY INITIATIVE*	

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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