UNCLASSIFIED

Department of Defense Fiscal Year (FY) 2010 Budget Estimates

May 2009

RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE

Volume 1 - Defense Advanced Research Projects Agency

UNCLASSIFIED

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DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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Defense-Wide
FY 2010/2011 President's Budget
Exhibit R-1
(Dollars in Thousands)

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

Date: 30 APR 2009

Line No	Program Element Number	Item	Act	FY 2008	FY 2009	FY 2010	SEC
2	0601101E	Defense Research Sciences	01	168,005	202,487	226,125	U
		Basic Research		168,005	202,487	226,125	
11	0602303E	Information & Communications Technology	02	184,664	250,626	282,749	U
12	0602304E	Cognitive Computing Systems	02	157,897	144,869	142,840	U
13	0602383E	Biological Warfare Defense	02	64,127	56,139	40,587	U
17	0602702E	Tactical Technology	02	260,219	352,924	276,075	U
18	0602715E	Materials and Biological Technology	02	297,030	282,896	268,859	U
19	0602716E	Electronics Technology	02	181,321	199,396	223,841	U
		Applied Research		1,145,258	1,286,850	1,234,951	
30	0603286E	Advanced Aerospace Systems	03	55,256	87,619	338,360	U
31	0603287E	Space Programs and Technology	03	146,494	226,394	200,612	U
46	0603739E	Advanced Electronics Technologies	03	163,386	199,504	205,912	U
50	0603760E	Command, Control and Communications Systems	03	242,540	328,073	293,476	U
51	0603764E	Land Warfare Technology	03	19,104			U
52	0603765E	Classified DARPA Programs	03	186,582	196,164	186,526	U
53	0603766E	Network-Centric Warfare Technology	03	132,962	154,015	135,941	U
54	0603767E	Sensor Technology	03	170,518	214,582	243,056	U
55	0603768E	Guidance Technology	03	114,752	107,979	37,040	U
		Advanced Technology Development (ATD)		1,231,594	1,514,330	1,640,923	
145	0605502E	Small Business Innovative Research	06	74,569			U

Defense-Wide
FY 2010/2011 President's Budget
Exhibit R-1
(Dollars in Thousands)

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

Date: 30 APR 2009

Line No	Program Element Number	Item	Act	FY 2008	FY 2009	FY 2010	SEC
154	0605897E	DARPA Agency Relocation	06		27,924	45,000	U
155	0605898E	Management HQ - R&D	06	51,480	48,568	51,055	U
163	0305103E	Cyber Security Initiative	06		49,865	50,000	U
		RDT&E Management Support		126,049	126,357	146,055	
		Total Research, Development, Test & Eval, DW		2,670,906	3,130,024	3,248,054	

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency **RDT&E Budget Item Justification**	**DATE:** May 2009
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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	168.005	202.487	226.125						Continuing	Continuing
BLS-01: BIO/INFO/MICRO SCIENCES	43.317	53.027	53.825						Continuing	Continuing
CCS-02: MATH AND COMPUTER SCIENCES	23.109	38.634	50.678						Continuing	Continuing
ES-01: ELECTRONIC SCIENCES	59.105	60.145	68.860						Continuing	Continuing
MS-01: MATERIALS SCIENCES	42.474	50.681	52.762						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.

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 1 - Basic Research	**R-1 ITEM NOMENCLATURE** PE 0601101E DEFENSE RESEARCH SCIENCES

(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.

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	174.996	195.657	226.125	
Current BES/President's Budget	168.005	202.487	226.125	
Total Adjustments	-6.991	6.830	.000	
Congressional Program Reductions	.000	-4.550		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	11.380		
Total Reprogrammings	-2.200	.000		
SBIR/STTR Transfer	-4.791	.000		

Congressional Increase Details ($ in Millions)	FY 2008	FY 2009
Project: BLS-01, **American Museum of Natural History - Infectious Disease**	.000	2.000
Project: BLS-01, **Bio-Butanol Production Research**	.000	2.000
Project: CCS-02, **Institute for Information Security**	.000	2.500
Project: ES-01, **Ultra Photonics Program**	.000	1.280
Project: MS-01, **Advanced Materials Research Institute**	.000	2.400
Project: MS-01, **Institute for Collaborative Sciences Research**	.000	1.200

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 1 - Basic Research	**R-1 ITEM NOMENCLATURE** PE 0601101E DEFENSE RESEARCH SCIENCES

Change Summary Explanation

FY 2008
Decrease reflects transfer of the Alternative Futures at the Range Complex congressional add to the O&M, Defense-Wide account, the Nanocrystal Source Display congressional add to the RDT&E Army account, and the SBIR/STTR transfer.

FY 2009
Increase reflects reductions for Section 8101 Economic Assumptions offset by congressional adds (as identified above) and congressional reductions.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601101E DEFENSE RESEARCH SCIENCES	PROJECT NUMBER BLS-01

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
BLS-01: BIO/INFO/MICRO SCIENCES	43.317	53.027	53.825						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. This project is also providing the supporting basic research for the effort to revolutionize prosthetics.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Bio Interfaces (U) The Bio Interfaces program will support scientific study and experimentation, emphasizing the interfaces between biology and the physical and mathematical/computer sciences. This unique interaction will develop new mathematical and experimental tools for understanding biology in a way that will allow its application to a myriad of DoD problems. These tools will help exploit the advances in the complex modeling of physical phenomena such as Electro-Magnetic Pulse (EMP). 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 2008 Accomplishments:* - Developed new mathematical algorithms which strengthened the metagenomics approach to ecology using population genetics and the analysis of evolving populations. - Developed a mathematical theory for the occurrence of quantum mechanical structure in biology through horizontal gene transfer and recombination. - Developed new mathematical methods targeting complexity and variability in biological systems.	6.000	6.000	3.000	

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PROJECT NUMBER BLS-01	

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Test and verify theoretical mathematical formulations of the laws of biology on simple systems. - Compare gene regulatory modules involved in the growth and development of plants and animals for similar functionality. - Test and verify proposed mathematical theory of collective decision making in viruses. *FY 2010 Plans:* - Test and verify theoretical mathematical formulations of the laws of biology on multi-scale systems. - Complete development of 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)* *Previously funded under Bio Interfaces. (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 2008 Accomplishments:* - Determined primary physical factors accounting for explosive-induced traumatic brain injury in experimental models.	1.960	7.000	10.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**			**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 1 - Basic Research	**R-1 ITEM NOMENCLATURE** PE 0601101E DEFENSE RESEARCH SCIENCES		**PROJECT NUMBER** BLS-01

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Completed epidemiological study of factors associated with explosive traumatic brain injury in warfighters. *FY 2009 Plans:* - Create protection and mitigation strategies that greatly reduce the number and extent of traumatic brain injuries in warfighter population due to explosion. - Continue studies on blast effects as needed to determine underlying physiological causes of blast induced brain injury. - Verify causes of blast brain injury through observations in warfighter population. - Assess injurious role of electrical discharge from detonation of cased munitions on central nervous system. *FY 2010 Plans:* - Refine protection and mitigation strategies and transition for use in theater and by military medical Services. - 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. - Develop devices and diagnostic platforms for blast brain injury in theater as needed.				
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, particularly to harsh environments, and the factors employed by the organism to assemble and manufacture complex biological subsystems. The unique stability afforded biological systems in their ability to adapt to wide extremes of physical and endurance (e.g., heat, cold, and sleeplessness) parameters will be examined and exploited in order to engineer stability into biological systems required for the military (such as blood, bioengineered tissues or other therapeutics). A key new antibody technology will develop the ideal antibody master molecule	13.175	14.127	13.325	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
that maintains high temperature stability and controllable affinity for threat agents. In addition, the fault tolerance present in biological systems will be exploited in order to assemble and manufacture complex physical and multi-functional systems, both biological and abiotic (such as tissue constructs designed for reconstructive surgery). These systems include novel load-bearing bio-interactive materials and composites for repair of severe hard tissue trauma, including complex bone fractures. Further activity in this area will investigate the adaptability of the brain to information processing and situational awareness. Applications to Defense systems include the development of chemical and biological sensors, and improved battlefield survivability of the warfighter. *FY 2008 Accomplishments:* - Decreased fibrotic collagen synthesis at a wound by twenty percent in an experimental model. - Developed strategies for production of ten red blood cell units per week for four weeks in an automated closed culture system using a non-renewing (replaceable) progenitor cell population. - Developed components for mathematical model for fracture putty/bone biomechanics. - Formulated chemistry for novel resorbable wet adhesives with the mechanical properties of natural bone, for inclusion into fracture putty formulation. - Formulated components for fracture putty which approximates the mechanical properties and internal structure of natural bone. *FY 2009 Plans:* - Begin demonstration of ten blood cell units per week for four weeks in an automated closed culture system using a non-renewing (replaceable) progenitor cell population. - Enhance or produce artificial cell membranes to control, repair and improve cellular processes in the warfighter. - Demonstrate in vitro construction of multicellular tissue using one or more non-contact cell positioning approaches. - Develop complete mathematical model for fracture putty/bone biomechanics. - Develop novel resorbable wet adhesives with the mechanical properties of natural bone, for inclusion into fracture putty formulation.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Develop fracture putty which approximates the mechanical properties and internal structure of natural bone. - Demonstrate mechanical properties of fracture putty for in vitro model of bone fracture. - Develop a functionalized abiotic “patch” to integrate into a cell membrane to direct cell control. - Demonstrate integration of pigment melanocytes into engineered skin. - Develop engineered fat tissue positive for expression of adipocyte-specific biomarkers lipase and fatty acid-binding protein. - Demonstrate multilayer construction of engineered fat constructs. *FY 2010 Plans:* - Develop a controlled permeability pore for selective delivery of agents to the cell interior. - Enhance or produce artificial cell membranes to repair, restore, and enhance cellular processes in the warfighter. - Demonstrate degradation of fracture putty into harmless resorbable by-products. - Demonstrate compatibility of fracture putty with existing osteoinductive formulations. - Demonstrate fracture putty in both small and large animal models of bone fracture. - Formulate protocols for expanded large animal studies of fracture putty. - Demonstrate antibody stability capability at 60 degrees centigrade and select for antibody affinity with a binding constant (KD = dissociation constant) greater than 10 to the eighth.				
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	10.250	10.500	8.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
insects that will extract power, control locomotion, and also carry DoD relevant sensors. In addition, research will be conducted in the interaction, at the nanoscale, of biotic and abiotic materials and functions, a critical aspect in the development of advanced prosthetics. *FY 2008 Accomplishments:* - Constructed an in vivo map of the feature sensitivity of populations of primary visual cortical neurons using nanochannel glass recordings and two-photon microscopy techniques. - Investigated how object representation in the mammalian inferotemporal cortex is computed from downstream visual system (V4) inputs using tools from topology, geometry, and statistics. - Demonstrated autonomous locomotion control via RF control for an un-tethered cyborg. - Designed three enzymes with catalytic activity greater than 105 for known chemistries. - Designed two protein-protein binding pairs including new support scaffolds. *FY 2009 Plans:* - Create a functional model of portions of the mammalian object recognition pathway that is biologically valid and suitable for translation to algorithm development. - Optimize Micro Electro Mechanical Systems (MEMS) components for locomotion control, communications and power generation to consume less power and to reduce size, weight and cost. - Apply protein design methodology to perform region-specific nitration chemistry. - Develop a protein that inhibits the activity of influenza by preferential binding. *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. - Extend catalytic activity of de novo designed enzymes to one billion for known chemistries. - Develop de novo protein countermeasure to degrade oximes.				
Human Assisted Neural Devices	10.332	10.900	12.500	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

(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 the ability to improve decision making in a variety of DoD applications including imagery analysis. In addition, this thrust will provide an understanding of how the brain adapts as it learns. This understanding will be translated into improved training approaches that allow transition from novices to expert in military tasks such as marksmanship to be accomplished with minimum effort and time.

FY 2008 Accomplishments:
- Identified the specific brain networks and regions involved in the generation of expert performance; tracked and classified progression from novice to expert level using functional neuroimaging techniques.
- Described the progression from novice to expert level using functional neuroimaging techniques.
- Investigated non-invasive interventions to increase the speed of expertise development including neurophsyiologically-driven training regimens, neurally optimized stimuli, and stimulatory/modulatory interventions.
- Analyzed how the brain encodes and responds to vibratory tactile stimuli in order to improve neural prosthetic devices.
- Developed an artificial interface between an external vibratory sensor and the neural processes used to identify and respond to vibratory sensation.
- Decoded intended motor signal from primates in a reaching and grasping task, resulting in movement of robotic wrist and hand.
- Improved upon existing algorithmic techniques of decoding neural function in order to do work through robotic devices, resulting in incremental gains in speed and accuracy.

FY 2009 Plans:
- Optimize non-invasive neuroscience interventions that will result in a two-fold increase in the speed of expected development and dramatically accelerate the transition from novice to expert in key military tasks.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Explore the extrapolation of task specific acceleration techniques from limited domains to wider, more general training applications. - Develop both task-specific and task-independent methods and strategies for neurophysiology-based learning acceleration applicable across multiple domains. - Identify memory neural codes that are specific to critical work related tasks, enabling possible potential memory restoration in a brain-wounded warfighter. - Verify that neural codes for short-term matching task among rodents are similar. - Create an interface that enables performance of a complex motor/sensory task through an assistive device without using either motor or sensory function. - Map dynamic functional motor and sensory networks and develop methods for characterizing brain-wide sensory/motor tasks. *FY 2010 Plans:* - Demonstrate learning acceleration techniques feasible for use across a broad range of individuals and explore the potential for group/team learning paradigms for increased quantity of expertise production. - Attempt to 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. - 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.				
Mathematics of the Brain (MoB)* * Previously funded under Human Assisted Neural Devices (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	.000	2.500	2.500	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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. Finally, this program will establish a functional mathematical basis on which to build future advances in cognitive neuroscience and computing capabilities across the DoD. *FY 2009 Plans:* - Leverage recent advances in neuroscience and mathematics to construct an integrated mathematical model of the brain that is consistent and predictive, rather than merely biologically inspired. - Develop a theory that overcomes the difficulties present in traditional approaches, such as artificial intelligence and artificial neural networks. Theory should be: biologically-consistent, generalizable, scalable, dynamic and not dependent on computer based data transfer techniques. *FY 2010 Plans:* - Validate models developed from new theories for functional consistency with brain performance including learning, memory (both long term and associative), recall and simultaneous task/process execution. - Implement these mathematical theories into hardware and demonstrate consistent performance on predetermined brain functions.				
Silent Talk (U) Silent Talk will allow user-to-user communication on the battlefield without the use of vocalized speech through analysis of neural signals. The brain generates word-specific signals prior to sending electrical impulses to the vocal cords. These signals of “intended speech” will be analyzed and translated into distinct words, allowing covert person-to-person communication. This program has three major goals: a) to attempt to identify electroencephalography patterns unique to individual words, b) ensure that those patterns are generalizable across users in order to prevent extensive device training, and c) construct a fieldable pre-prototype that would decode the signal and transmit over a limited range.	.000	.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Identify electroencephalography (EEG) patterns unique to a subset of 100 words commonly used by the warfighter community.				
Bacterial Ghost Influenza Vaccine Development *FY 2008 Accomplishments:* - Continued development of novel genetically inactivated bacterial-based vaccines to overcome disadvantages of egg-based vaccines.	1.600	.000	.000	
Bio Butanol Production Research *FY 2009 Plans:* - Investigate bio-butanol production capabilities.	.000	2.000	.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, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**		**DATE:** May 2009
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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CCS-02: MATH AND COMPUTER SCIENCES	23.109	38.634	50.678						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 2008	FY 2009	FY 2010	FY 2011
Foundational Computer Science	15.173	8.994	12.778	

*Formerly Computer Exploitation and Human Collaboration.

(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 that will allow warfighters and commanders of the future to interact in a natural way with computers, enable a new generation of collaboration methods and information acquisition, and provide intelligent seamless exchange of information in a world where computing devices are ubiquitous and heterogeneous. The Foundational Computer Science program is also addressing the need for highly reliable and trustworthy mission-critical information systems. Scalable formal methods and other techniques will be used to guarantee the reliability and robustness of a design while also developing techniques to reduce the complexity and cost.

(U) The Information Theory for Wireless Mobile Ad Hoc Networks (ITMANET) effort is creating an information theory for ad hoc mobile wireless networking in the absence of wired infrastructure. Issues

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**		**DATE:** May 2009
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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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. (U) The Foundational Computer Science program is also supporting research on the foundations of artificial intelligence: machine learning and reasoning. For machine learning, the focus is on techniques that can efficiently process and “understand” massive data streams. 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. (U) For machine reasoning, the Foundational Computer Science program is addressing problems that are inherently computationally complex and, in many cases, intractable. The game of Go provides an ideal platform for creating the heuristic approaches and tools necessary to enable effective, practical machine reasoning about problems that typically require either enormous computer resources or simplification of the problem 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. *FY 2008 Accomplishments:* - Developed and analyzed tractable and insightful metrics and network models that expand the definition of information theory to encompass the degrees of freedom, constraints and dynamics inherent to wireless networks. - Developed new upper bounding techniques for MANET capacity and other performance metrics, and evaluated these bounds for small to medium-sized networks. - Developed new achievability results for key performance metrics by optimizing dynamic node cooperation and resource allocation over available degrees of freedom.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Used rate distortion theory and network utilization to optimize the interface between networks and applications. *FY 2009 Plans:* - Predict performance in terms of throughput-delay-reliability for a specific pre-defined MANET. - Develop new achievability results for key performance metrics based on networks designed as a single probabilistic mapping with dynamics over multiple timescales. - Assess the potential for the recently developed Upper Confidence Tree (UCT) algorithm to search trees with high branching factor. - Develop features for spatial description of board position for the game of Go. - Develop algorithms and architectures for learning in a deep hierarchy, each level of which would contain invariant representations of expected data. *FY 2010 Plans:* - Predict performance in terms of throughput-delay-reliability for modest-sized MANETs with and without feedback. - Develop upper-bounding techniques that go beyond the classical bounds and inequalities for MANETs. - 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. - 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. - Create non-traditional computing architectures that go beyond the currently deployed instruction-set architectures.				
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 DoD, and enables the transition of those ideas and applications by promoting joint university, industry, and	6.936	9.890	11.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
government projects. The CSSG project formalizes and focuses this research for efficiency and greater effectiveness. *FY 2008 Accomplishments:* - Developed extensive collaboration among civilian computer scientists and DoD technologists and customers. - Developed software models of human skin architecture including sensory neural system. - Developed new computational learning theory, including learning from noisy data, to enhance algorithms for random noise tolerance. - Developed software with increased capability and dependability, by combining static tools and human insight at the architectural level to defeat attacks. - Developed a process for networking wireless imaging systems and other wireless sensors emphasizing change detection and medical applications. *FY 2009 Plans:* - Identify and explore new computer science challenges that, when addressed, will yield extraordinary advances for DoD applications. - Develop a novel agent based simulation environment that will allow 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. - Develop fundamental algorithms with provable guarantees of correctness and efficiency to enable effective learning from incomplete data and data corrupted with noise. - Explore bio-inspired computing emphasizing evolutionary computation and artificial neural networks (ANNs) to solve difficult real world tasks such as autonomous guidance of vehicles. - Develop new approaches for management of network security, authentication, mobility, and handoff 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.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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.				
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 Plans:* - Build a mathematical model that theoretically confirms a viable procedure for constructing macroscopic 3-D solid objects with functional properties that have real world use. - Demonstrate externally-directed assembly of distinct macroscopic 3-D solids. - Demonstrate interlocking/adhesion of mesoscale particles to create bulk matter. - Demonstrate reversibility. *FY 2010 Plans:* - Optimize Programmable Matter properties. - Demonstrate Programmable Matter for selected applications.	.000	4.000	7.000	
Young Faculty Award (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	.000	8.500	15.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 Plans:* - Initiate activities for research of new concepts for enhancing microsystem technologies. - Develop 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.				
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 High School Science Study Group/CS 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. *FY 2008 Accomplishments:* - Assembled a panel of academic computer scientists to identify potential areas of interest to high school students. - Established student study groups to gauge the attractiveness of the proposed ideas to students. - Conducted student evaluation of potential research to include robotics for traffic and vehicle management, robots for environmental surveillance and conservation, and object recognition for the blind.	1.000	2.000	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 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. *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.				
Focus Areas in Theoretical Mathematics (FAThM)* *Previously included in High Performance Algorithm Development, PE 0602702E, Project TT-06. (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 Plans:* - Establish and exploit new relations between number theory and symmetry groups of fundamental particles. - Tie 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.	.000	1.350	1.400	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Establish and exploit new relations between the analytic foundations of symmetry and algebraic computation.				
23 Mathematical Challenges* *Previously included in High Performance Algorithm Development, PE 0602702E, Project TT-06. (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 Plans:* - Develop advances in stratified Morse Theory and metric, algebraic, and hyperbolic geometries to investigate complex fluid flow. - Build and exploit 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 approach 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. - Develop a theoretical analysis of idealized data assimilation problems in an identified complex system.	.000	1.400	1.500	
Institute for Information Security *FY 2009 Plans:* - Complete information security initiatives.	.000	2.500	.000	

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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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
ES-01: ELECTRONIC SCIENCES	59.105	60.145	68.860						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 2008	FY 2009	FY 2010	FY 2011
University Photonic Research (UPR) Centers	2.778	.000	.000	
(U) The University Photonic Research (UPR) Centers program was dedicated to coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components. Such components are critical to enhancing the effectiveness of military platforms that provide warfighter comprehensive awareness and precision engagement. Topics researched included emitters, detectors, modulators and switches operating from infrared to ultraviolet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules. *FY 2008 Accomplishments:* - Designed and fabricated prototype modules using the system-on-a-chip approach.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Developed testbeds capable of fully measuring and characterizing the mixed technologies implemented in the chip-scale components. - Performed fundamental, long-term research in integrated photonics science and engineering, to realize higher performance, lower energy, greater environmental stability, and adaptive behavior requirements that are needed for future DoD relevant applications. - Advanced newly developed photonics technologies and associated tools toward eventual insertion in DoD applications via industrial collaboration.				
Semiconductor Technology Focus Centers (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 Corp (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 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 2008 Accomplishments:* - Demonstrated, via simulation, integration of nanometer-scaled devices into circuit macro functions that have application to military sensor signal processing or advanced communications protocols. - Explored integration processes for incorporating high mobility materials as transistor channels in deeply scaled field-effect transistors. - Explored new materials and fabrication approaches to scale devices below 10 nanometers (nm). *FY 2009 Plans:* - Develop novel device fabrication and integration approaches for deeply scaled transistors and architectures for high performance mixed signal circuits for military needs.	10.200	20.000	20.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Develop 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.				
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 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 2008 Accomplishments:* - Continued exploration of fundamental quantum systems. *FY 2009 Plans:* - Develop novel approaches to improving decoherence times. - Devise full characterization and manipulation of entangled quantum systems. - Formulate 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.	4.416	9.389	14.135	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
N/MEMS Science and Focus Centers	9.916	10.000	10.000	
(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 DoD needs. Industrial cost sharing is an important element of the overall effort. *FY 2008 Accomplishments:* - Fabricated non-lithographic MEMS. - Developed an understanding of fluidics on a nanoscale. *FY 2009 Plans:* - Develop MEMS enabled reconfigurable electronics. - Develop 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.				
Semiconductor AlGaN Injection Lasers (SAIL)	1.049	3.168	.000	
(U) This program will demonstrate semiconductor injection lasers based on Aluminum Gallium Nitride (AlGaN). In addition to demonstrating the laser performance in terms of threshold current density, operating voltage, and power output, the Semiconductor AlGaN Injection Lasers (SAIL) program will concentrate on reliability assurance and will produce lasers with stable operating characteristics. The emission wavelengths of interest are 340 nanometers and 280 nanometers. The U.S. military has a pressing requirement for compact, reliable, and cost-effective detection of bio-agents. This need is made apparent by the growing specter of the potential use of weapons of mass destruction by either terrorists or unfriendly nations. Semiconductor lasers, with their intrinsic high brightness and power will enable stand-				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
off detection applications, such as bio Light Detection and Ranging (bioLIDAR), and will greatly enhance point-detection of aerosolized bio-agents. *FY 2008 Accomplishments:* - Demonstrated pulsed lateral overgrowth of Aluminum Nitride. - Demonstrated optically pumped lasing in Aluminum Nitride. - Demonstrated high quality pulsed lateral epitaxy of Aluminum Nitride devices. *FY 2009 Plans:* - Demonstrate 340 nanometer wavelength lasers operating at room temperature under pulsed conditions. - Demonstrate stimulated emission for 280 nanometer wavelength structures.				
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 injection lasers operating Continuous Wave 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 2008 Accomplishments:* - Demonstrated first room temperature plasmonic feedback sub-wavelength emission: Threshold power of 1 milliwatt. - Demonstrated novel new cavity design exhibiting tight confinement of plasmon modes and low-loss dielectric modes.	3.525	5.313	4.926	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Demonstrate novel heterostructures capable of gain. - Establish minimum Q factor for laser threshold. *FY 2010 Plans:* - Demonstrate sub-wavelength lasers. - Determine threshold gain under injection.				
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 2008 Accomplishments:* - Selected initial fabrication materials, mechanisms, and processes for optimal properties. - Completed preliminary design of specialized processing equipment. *FY 2009 Plans:* - Demonstrate 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.	4.528	10.995	10.799	
Quantum OptoMechanics Integrated on a Chip (U) The objective of this 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	.000	.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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.				
Centers for Integrated Photonics Engineering Research (CIPhER) (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	.000	.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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.				
Molecular Photonics (MORPH) (U) The Molecular Photonics (MORPH) program explored large dendritic and other highly branched organic molecules that offer 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 2008 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.	8.000	.000	.000	
Illinois Institute of Technology	1.040	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) The Illinois Institute of Technology program explored new approaches to advanced electronics technology. *FY 2008 Accomplishments:* - Initiated development of advanced electronics technologies.				
Advanced Photonic Composites Research (U) The objective of Advanced Photonic Composites Research program is to develop advanced optical composites for defense applications. *FY 2008 Accomplishments:* - Transitioned nano-engineered materials and composites into DoD relevant devices with a specific focus on advancing infrared detectors and energy harvesting structures. - Developed and commercialized composite technology in integrated optics. *FY 2009 Plans:* - Continue photonic composite development.	3.253	1.280	.000	
Nanoscience Nanotechnology Institute (U) The Nanoscience Nanotechnology Institute explored new approaches to nanoscience research. *FY 2008 Accomplishments:* - Initiated nanoscience research.	2.400	.000	.000	
Focus Center - Government Industry Cooperative University Research (GICUR) (U) The Focus Center - Government Industry Cooperative University Research (GICUR) program compliments the goals and objectives of the Semiconductor Technology Focus Centers. All plans are identical. All funding is applied to the Semiconductor Technology Focus Center program.	8.000	.000	.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 1 - Basic Research	R-1 ITEM NOMENCLATURE PE 0601101E DEFENSE RESEARCH SCIENCES	PROJECT NUMBER ES-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Explored integration processes for incorporating high mobility materials as transistor channels in deeply scaled field-effect transistors. - Explored new materials and fabrication approaches to scale devices below 10 nanometers.				

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, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification									DATE: May 2009	
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 1 - Basic Research				R-1 ITEM NOMENCLATURE PE 0601101E DEFENSE RESEARCH SCIENCES					PROJECT NUMBER MS-01	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
MS-01: MATERIALS SCIENCES	42.474	50.681	52.762						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 2008	FY 2009	FY 2010	FY 2011
Nanoscale/Biomolecular and MetaMaterials	8.000	12.583	11.829	

(U) The research in this thrust area exploits advances in nanoscale and bio-molecular materials, including computationally based materials science, in order to develop unique microstructures and 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 2008 Accomplishments:

- Developed efficient computational methods that correctly predict the properties of excited electronic states in high intensity laser.
- Achieved mid-wave infrared optical transmission comparable to that of spinel and worked toward achieving a composite material with mechanical properties comparable to those of sapphire in yttria-magnesia nanocomposite material.
- Achieved first-ever optical model for nanomaterials of interest and transitioned it to the research community.
- Achieved yttria, nano silicon carbide optical ceramics with required strength of sapphire and worked toward optical properties of spinel.

FY 2009 Plans:

- Demonstrate automated laser beam front diagnostic and adaptive beam correction.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Demonstrate simultaneously infrared optical transmission comparable to spinel and mechanical properties comparable to sapphire in 75mm discs. - Develop new materials with both optical properties and strength into 75mm flat discs. - Characterize the material properties of 75mm discs through testing in relevant environments. - Demonstrate the ability to provide surface strengthening through compressive materials. - Investigate new methods of altering diatom structures and adapting diatom materials to facilitate new sensors and devices. *FY 2010 Plans:* - Initiate development 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. - Characterize the material properties of non-hemispherical domes. - Develop inexpensive processing techniques to create customized diatom derived sensors and devices. - Ion: demonstrate ability to affect airflow around the surface of an airfoil using ions accelerated across multiple points to generate an airstream on the surface of the airfoil. - Radiometer: demonstrate ability to produce significant forces on aerofoil-shaped surfaces. - Establish the material science of charged matter by developing underlying technology and defining range of applicability. - Demonstrate in a laboratory environment charged matter properties including superadhesion, frictionless surfaces, and resistance to electrostatic charging.				
Engineered Bio-Molecular Nano-Devices and Systems (U) The Engineered Bio-Molecular Nano-Devices and Systems program seeks to develop and demonstrate engineered bio-molecular nano-scale devices that harness nature's nanophotonic structures to enable controllable photonic devices at visible wavelengths, enable real time observation and analysis of bio-molecular signals, thus enabling single molecule sensitivity with the simultaneous exploitation of the temporal domain (i.e., stochastic sensing). Arrays of such devices will enable an order of magnitude (10 to 100 times) reduction in the time required for analysis and identification of known and unknown	6.574	10.698	10.500	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(engineered) molecules. The potential to engineer lightning will be investigated. This program will also develop novel nanomaterials for exquisitely precise purification of materials, enabling such diverse applications as oxygen generation and desalination. 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 2008 Accomplishments:* - Demonstrated a stochastic sensing system using a mutant protein pore in a non-laboratory setting. - Demonstrated a probability of detection greater than 99.5% and an extremely low false alarm rate with Chemical Warfare Agents (CWA) simulants and CWA interferent simulants. - Developed and prototyped a multi-element (4) array of stable sensor elements. - Used ultra-high-speed cameras, electric field mills, radio frequency (RF) sensors and scintillation detectors to simultaneously record the development of lightning stepped leaders, while simultaneously measuring associated X-rays, electric fields, and magnetic fields in order to improve lightning initiation and propagation models. - Used lightning initiation and propagation models to characterize the conductivity of the stepped leader channel just prior to the initiation of lightning and the first return stroke for troop, asset, and ordnance protection for surface fields greater than 4 kilovolts per meter (KV/m) and for surface fields greater than 6 KV/m. - Designed, fabricated and integrated a prototype dual-energy filter into the Volumetric Angio Computed Tomography (VAC) imaging test bed to allow dual energy imaging and the detection of occult bleeding in battlefield casualties. - Established and successfully tested a Figure-of-Merit for multiple simulated filter configurations and the imaging testbed filter implementation. - Derived a new image reconstruction algorithm that meets de-blurring sampling requirements. *FY 2009 Plans:* - Develop novel mathematical tools that enable design of revolutionary molecular structures and tailoring of properties.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Design novel structures based on these mathematical tools and correlate geometric characteristics with spectroscopic characteristics. - Identify configurational properties of candidate structures that result in unique spectroscopic characteristics. - Construct preliminary lightning safety model from the ground-based measurements in FY 2008 for the critical conditions of safe military operations for personnel and ordnance. - Develop fabrication processes for a reproducible, transmission anode with two times increased yield and efficiency and suitable for integration into the sealed transmission anode X-ray tube. - Select the best overall transmission anode fabrication process for further development. *FY 2010 Plans:* - Calculate the quantum mechanical characteristics of these mathematically inspired novel molecular structures developed in FY 2009. - Characterize the electronic and vibrational properties of candidate structures from their quantum properties. - Verify via simulation that selected materials possess desired properties. - Use ground-based, arial and space-based assets to measure optical, RF, magnetic, X-ray and gamma ray events associated with rocket triggered lightning. - Develop, validate and improve a 3-D model of critical conditions and processes in clouds and the atmosphere. - Develop a set of candidate biological, physical, and social systems for investigation and construct a qualitative description of their commonalities. - Develop an initial simulation system for implementing the concepts developed. - Develop a quantitative theory that describes the fundamental features of intelligence evidenced in the various systems examined. - Low cost, lightweight, portable photovoltaics (PoP) will explore all aspects of portable photovoltaic (PV) devices: light acquisition, energy capture, carrier extraction, robust and durable portability, and flexibility to identify most advantageous breakthroughs for portable PV devices. - Demonstrate understanding of interaction of nano-structure with light and gas molecules. - Demonstrate initial fabrication of nanophotonic structures.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**			**DATE:** May 2009	
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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Atomic Scale Materials and Devices	13.100	13.800	14.901	

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

FY 2008 Accomplishments:
- Demonstrated Rubidium atomic clock with line-width below 20 Hz (less than twenty percent natural line-width).
- Demonstrated quantum kicked rotor technique to reduce decoherence in atom interferometer.
- Demonstrated high-throughput optical lattice systems for improved simulation time and stable frequency metrology.
- Developed real-time, modular system for experimental control, monitoring, and data acquisition.
- Designed optical system to produce flat-top transverse beam profile for homogeneous optical lattice.
- Demonstrated production of bi-photon pairs and arbitrary amplitude modulation of bi-photon wavefunction.

FY 2009 Plans:
- Demonstrate rotationally sensitive interferometer with sensitivity greater than one radian per earth rotation rate.
- Emulate two-dimensional (2-D) Bose-Hubbard Model phase diagram in less than twelve hours that confirms theoretical calculations.
- Install flat-top beam profile system in experimental chamber; verify production of homogeneous optical lattice potential.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Engineer strong optically-induced absorption materials for all-optical switch (or equivalent device) with ultra-low energy dissipation per operation. - Design all-optical switch (or equivalent device) based on optically-induced absorption. - Develop theoretical techniques to extract relevant model-independent thermodynamic quantities from ensemble absorption images. - Demonstrate non-local modulation of bi-photon wavefunction and demonstrate single photon non linear switch. - Establish the parameters necessary to achieve high levels of deuterium loading with a minimum of electrochemical power. - Initiate development of the capability to reproducibly generate significant increases in excess heat using electrochemically stimulated, highly deuterated palladium. *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 core materials fabrication techniques that will enable extremely low-power, extremely high density, all-oxide, transistor-like switches with a ferroelectric gate and a high density, 2-D interfacial oxide electron gas exhibiting metal-insulator transition in response to an applied gate voltage. - Model how these transistor-like devices will support corresponding device architecture for advanced reconfigurable logic and memory. - 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. - Quantify the effects of impurities in palladium substrate material on the capability to generate excess heat.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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. - Establish the effects of surface area and crystal orientation on degree of deuterium loading and the loading/relaxation dynamics and correlate these effects with increases in excess heat generated. - 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 soft X-rays with specific states of orbital angular momentum. - Initiate a series of experiments using the High Frequency Active Auroral Research Program (HAARP) facility to study ionospheric and trans-ionospheric phenomena, including optimization of high frequency to very low frequency conversion efficiency, generation and propagation and characterization of artificial ducts, and triggering and characterization of specific ionospheric instabilities.				
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 2008 Accomplishments:* - Developed understanding of nanoparticle shape and its effect on SERS enhancements; examined high quality resonators for SERS applications.	5.000	8.000	8.475	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Develop 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.				
Casimir Effect Enhancement (CEE) (U) This program's goal is to manipulate materials properties and geometries in order to enable repulsive Casimir forces at interfaces. This can lead to increased reliability in Micro Electrical Mechanical Systems (MEMS) devices by eliminating stiction, reduced drag and increased fuel efficiency in all military systems (boats, airplanes, etc.), or enhancing any system where attractive forces hinder overall performance. *FY 2010 Plans:* - Model potential systems where Casimir forces can be manipulated. - Experiment to confirm ability to reduce Casimir force. - Demonstrate nanomechanical device with observable, repeatable ten percent reduction in adhesive forces.	.000	.000	4.057	
Dynamics-Enabled Frequency Sources (DEFYS) (U) The Dynamics-Enabled Frequency Sources (DEFYS) program will develop components to enable navigation and control systems for advanced weapons systems operating in high-G environments. DEFYS will revolutionize frequency sources by moving to nanoscale mechanical devices enabling low-phase noise performance better than Quartz from an easily integrated package. The program will use novel mechanisms in nonlinearities and background noise, while incorporating temperature stability and acceleration sensitivity to provide performance exceeding currently predicted limits. *FY 2010 Plans:* - Demonstrate first mechanism, use nonlinearity to eliminate phase noise from amplifier jitter. - Work at state-of-art frequencies to facilitate concentration on novel mechanism.	.000	.000	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Quantum Sensors (U) The Quantum Sensors program developed approaches to exploit non-classical effects called entanglement to improve the resolution and range of military sensors. Quantum sensors retain the generally better propagation characteristics of long wavelength light while achieving the better spatial resolution of short wavelength radiation. Conventional classical sensors rely on light with shorter wavelengths, like blue light, to produce sharp images. As wavelengths increase, for example from blue to infrared, the classical resolution decreases. Quantum sensors will be able to retain high resolution as the wavelength increases using a non-classical effect called entanglement. Two broad classes of sensor are under consideration. Type I quantum sensors propagate entangled photons to a target and back to a detector, where quantum effects may enhance resolution. Type II quantum sensors propagate classical radiation to the target, and entangled photons are used within the detector to improve resolution. A third class of approach, based on ghost imaging, is also being explored. As the program transitions from the theoretical proof stage to the subsystem design stage in FY 2009 it will move to the Electronic Technology PE 0602716E, Project ELT-01. *FY 2008 Accomplishments:* - Continued studies of Type I, Type II, and ghost imaging sensor concepts to establish whether they are robust to military targets and environments. - Completed experiments on outdoor propagation of non-classical states.	4.800	.000	.000	
Comparative Genomics for National Security Goals/Infectious Disease Research *FY 2008 Accomplishments:* - Examined prognostic epidemiology using comparative genomics. - Developed software program for phylogenic analysis of DNA and other data using dynamic homology. *FY 2009 Plans:* - Promote community interaction and create user groups to test software program and improve system. - Identify parameters needed for research areas of transition partners.	1.000	2.000	.000	
Institute for Collaborative Sciences Research	.000	1.200	.000	

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 1 - Basic Research	PE 0601101E DEFENSE RESEARCH SCIENCES	MS-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Investigate a collaborative sciences research effort.				
Advanced Materials Research Institute *FY 2008 Accomplishments:* - Investigated use of nanoparticles and nanowires to improve chemical electron mobility and/or magnetic energy storage product relative to bulk materials. *FY 2009 Plans:* - Investigate nanoscale engineering of multiferroic materials, and implementation of voltage controlled ferromagnetism for micro- and nano-scale devices.	4.000	2.400	.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-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	184.664	250.626	282.749						Continuing	Continuing
IT-02: HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES	56.913	98.641	96.991						Continuing	Continuing
IT-03: INFORMATION ASSURANCE AND SURVIVABILITY	61.621	76.966	113.587						Continuing	Continuing
IT-04: LANGUAGE TRANSLATION	66.130	75.019	72.171						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

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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 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	230.385	254.009	234.676	
Current BES/President's Budget	184.664	250.626	282.749	
Total Adjustments	-45.721	-3.383	48.073	
Congressional Program Reductions	.000	-8.583		
Congressional Rescissions	-14.000	.000		
Total Congressional Increases	.000	5.200		
Total Reprogrammings	-25.413	.000		
SBIR/STTR Transfer	-6.308	.000		
TotalOtherAdjustments			48.073	

Congressional Increase Details ($ in Millions)	FY 2008	FY 2009
Project: IT-03, **Document Analysis and Exploitation**	.000	1.600
Project: IT-03, **Intelligent Remote Sensing for Urban Warfare Operations**	.000	2.400
Project: IT-03, **National Repository of Digital Forensic Intelligence/Center for Telecommunications and Network Security**	.000	1.200

Change Summary Explanation

FY 2008
Decrease reflects the Section 8042 rescission, the OSD AFRICOM and O&M reprogrammings, below threshold reprogramming actions and the SBIR/STTR transfer.

FY 2009
Decrease reflects reductions for Section 8101 Economic Assumptions offset by congressional adds (as identified above) and congressional reductions.

FY 2010

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Increases reflect additional funds in the High Productivity, High Responsive Architectures project for new architecture programs and increased emphasis on Information Assurance programs.

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COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 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	56.913	98.641	96.991						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 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. The resulting extreme computing systems will be capable of scaling from embedded to leadership class supercomputer systems. The most significant technical achievements that must be realized to obtain the goals of extreme computing are the enabling architectural advancements, pervasive low power approaches, low volume physical packaging, and effective programming of these systems. Numerous additional technical challenges must be resolved, including the reliability of “extreme computing” systems: embedded systems require a higher level of reliability and assurance than general-purpose systems because the failure of an embedded computing system can result in the loss of a deployed platform.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
High-Productivity Computing Systems (HPCS)	43.243	71.654	60.904	

(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 2008 Accomplishments:
- Completed design verification of some application-specific integrated circuits (ASICs), a critical step before releasing design to the very costly fabrication process.
- Developed and implemented operating system scaling and performance improvements so that existing operating systems can be leveraged, saving development costs, facilitating use of legacy code, and improving user productivity by preventing the need to learn a new operating system.
- Continued developing productivity tools and demonstrated early versions of productivity tools for the HPCS stakeholders to solicit their feedback.
- Conducted an HPCS software critical design review of each vendor.
- Evaluated vendor delivered design specifications.
- Explored opportunities to expand the user base for high-end computing.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Release the beta version application development software to HPCS stakeholders for evaluation and to provide familiarity with the software prior to system release thus reducing the learning curve upon system availability. - Fabricate and test several of the ASICs. - Continue to develop and implement operating system scaling and performance improvements. - Continue developing productivity tools. - Conduct critical design review of each HPCS vendor's system. - Begin 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 which provides confidence that the prototype (especially hardware/software integration) is on track for FY 2011 final demonstration. - Build out prototype hardware. - Integrate software onto hardware.				
Software Producibility (U) The Software Producibility program will reduce the cost, time, and expertise required to build large complex software systems. This includes new techniques for rapidly developing adaptive software that can be easily changed to conform to new software design and development tools, readily complies with new requirements, and readjusts dynamically to environmental perturbation. Improvements in compiler technology can greatly simplify application development by providing the capability to automatically and efficiently generate compiled code that effectively exercises the targeted computer system resources for a broad spectrum of military and industrial applications, and for computer systems that range from a single,	7.600	15.996	22.087	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
multi-core processor system to very large, multi-processor systems. Significant advances in software development technology will be made as new processor technologies such as multicore, stream, and the cloud computing paradigms become the norm for both military and civilian computing infrastructure. Security and service guarantees will be addressed. *FY 2008 Accomplishments:* - Developed tool chains to support preliminary flight control/vehicle management system and software-defined radio experiments. - Conducted a fault management design time experiment. - Conducted software-defined radio design-time and load-time adaptation experiments. - Investigated initial community-based concepts for characterization tools and self-assembling compiler elements. *FY 2009 Plans:* - Develop tool chains to support optimized verification, field update and security adaptation experiments. - Conduct optimized verification, field update and security adaptation experiments. - Investigate initial concept for characterization tools and self-assembling compiler elements. *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. - Create the initial common development environment and develop supporting technologies. - Demonstrate initial improved compiler approaches and characterization tools. - Create initial strategies for software frameworks to support multi-core, stream and cloud computing.				
Extreme Computing (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	6.070	10.991	14.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
scalable performance, productivity, physical size, power, programmability, data bandwidth, latency, and optimized data placement/storage. This includes creating the new Dynamic Random Access Memory (DRAM) architectural approaches that are essential if overall memory performance is to keep up with processor performance. Such DRAM improvements and other architectural breakthroughs are essential for processing time-critical applications having massive input-output requirements. 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 2008 Accomplishments:* - Identified and assessed the potential technologies necessary to provide the types of improvements essential to achieve extreme computing: non-von Neumann architectures; 3-D microelectronic structures; high-bandwidth/low-latency electrical and optical technologies; multiple-core processors; radically different packaging solutions; new memory and storage architectures; and non-intrusive interfaces. - Initiated a study to identify potential new hardware architectures and candidate approaches, such as master/slave methods where the “slave” collects and condenses data. *FY 2009 Plans:* - Investigate new memory architecture approaches that overcome the limitations of current DRAM. - Formulate new processor and memory architectures that will lead to extreme computing.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Analyze existing individual design tools, identify design tool gaps, establish approaches for a unified design development framework, and evaluate potential structured Application-Specific Integrated Circuit (ASIC) processing architecture concepts. - 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. *FY 2010 Plans:* - Develop new memory architecture approaches, develop enabling prototype critical memory and memory module technologies. - Develop the identified critical and processor technologies, system methodologies, and architectures to enable general-purpose computing systems to perform at extreme computing levels. - Develop the approaches, frameworks, initial architectural concepts and tool implementations essential to implement structured ASIC processing architectures and integrated application development environments. - Explore, develop, evaluate and perform initial simulations of techniques to enable computing systems to self-monitor their state and adapt in real time. - Develop architectural approaches for processing time-critical applications having massive input-output requirements.				

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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
IT-03: INFORMATION ASSURANCE AND SURVIVABILITY	61.621	76.966	113.587						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 2008	FY 2009	FY 2010	FY 2011
Next Generation Core Optical Networks (CORONET) (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, such as those provided by wavelength division multiplexing; 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 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	13.520	13.200	16.069	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

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 Next-Generation Core Optical Networks (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 2008 Accomplishments:

Next-Generation Core Optical Networks (CORONET)
- Established a common global core optical network topology.
- Developed the architectures and defined the network elements for a fast reconfigurable optical core network.
- Initiated development of protocols and algorithms to provide fast service setup, fast restoration from multiple network failures and guaranteed quality of service for a global core optical network.

Transmission, Switching and Applications for CORONET
- Completed a study on how to increase the spectral efficiency of existing optical networks by up to ten times.
- Completed a study to determine the impacts of emerging 100 Gbps Ethernet technology on next-generation optical networks.
- Initiated a study to examine migration strategies and associated software and hardware interfaces to enable new applications for next-generation core optical networks.
- Initiated a study of banded vs. channelized wavelength division multiplexing (WDM) transmission in spectrally efficient fiber-optic links.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: Next-Generation Core Optical Networks (CORONET) - Complete the development of protocols and algorithms, and develop 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. - Model and simulate a dynamically reconfigurable multi-terabit global core optical network. Transmission, Switching and Applications for CORONET - Initiate 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. - Architect a multi-terabit all-optical switch capable of fast switching of wavelengths and wavebands and of grooming wavelengths among wavebands. *FY 2010 Plans:* Next-Generation Core Optical Networks (CORONET) - Initiate the development of the network control and management software such that the final product will be transitioned and implemented in current 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.				
Intrinsically Assured Mobile Ad-Hoc Networks (IAMANET)* *Formerly Dynamic Quarantine of Computer-Based Worms (DQW) and Dynamic Quarantine of Computer-Based Worms and Defense Against Cyber Attacks on Mobile Ad-hoc Network Systems (DCAMANET).	7.515	9.432	14.543	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Intrinsically Assured Mobile Ad-Hoc Network (IAMANET) program is a continuation of 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 will directly support 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 will be interoperable with fixed networks and may also have potential applicability to the broader DoD network architecture. *FY 2008 Accomplishments:* Intrinsically Assured Mobile Ad-Hoc Network (IAMANET) - Developed preliminary designs for an assurable network infrastructure (architecture, control and management, algorithms and policies). - Established an independent IAMANET red team to critique the performers during the design of the assurable network infrastructure. Dynamic Quarantine of Computer-Based Worms (DQW) - Integrated DQW system into DoD enterprise networks tool suite. - Integrated DQW prototype into DoD enterprise solution tool suite.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Tested integrated system against full-spectrum nation state worm threat. *FY 2009 Plans:* Intrinsically Assured Mobile Ad-Hoc Network (IAMANET) - Complete the designs and development of the assurable network infrastructure. - Test and evaluate the performance of the assurable network infrastructure on a 96-node networking simulation. Dynamic Quarantine of Computer-Based Worms (DQW) - Harden system against directed attacks. - Improve detection and response capabilities discovered from testing. - Test integrated system on operational network. - Test integrated system against red teams (attack teams) during Combatant Command exercise. - Transition technology to DoD. *FY 2010 Plans:* Intrinsically Assured Mobile Ad-Hoc Network (IAMANET) - Conduct red team attacks and assessments of the assurable network infrastructure to verify the network's integrity, availability, reliability, confidentiality, and safety. - Initiate the design, development and integration of a secondary defensive subsystem (similar to what was developed under DCAMANET and the Dynamic Quarantine of Worms) with the assurable network infrastructure and a host radio. - Initiate design and development of trusted hardware components for specific key functions.				
Trustworthy Systems (U) The goal of the Trustworthy Systems program is to provide foundational trustworthy computer platforms for Defense Department computing systems. This program seeks to develop technologies such as novel computer processing architectures, hardware, firmware, or microkernels to guarantee network and workstation security and will initially focus on network-based monitoring approaches that provide maximum coverage of the network with performance independent of the network size. This program will	11.300	9.910	11.090	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
focus on the development of feedback control-based solutions to software vulnerabilities and gateway-and-below network traffic monitoring approaches that scale with network size. Operational goals of the network-monitoring component include: 1) improved probability of detection/probability of false alarm performance and 2) scalability to future gateway line speeds. The desired result is to allow software to be imperfect while mitigating catastrophic failures. Technical challenges include remotely monitoring mission-critical servers using virtual machines, tracking the trustworthiness of the server, and controlling the server to return it to trustworthiness states. Primary end users identified to date include Strategic Command Joint Task Force/Global Network Operations and Headquarters Pacific Command. Transition partners include National Computer Security Center, Naval Information Warfare Activity, and Defense Information Systems Agency. *FY 2008 Accomplishments:* - Developed scalable formal methods to verify complex hardware/software. - Researched network-sensitive approaches to monitor, and trustworthy controllers to control, how and when information is disseminated across the network based on network performance, load, criticality, and target capacity. *FY 2009 Plans:* - Investigate the use of new virtual machine hardware architectures to develop a feedback loop that enables the host to monitor and control its behavior in the presence of untrustworthy software. - Investigate secure hardware designs, software architectures, and code assessment technologies. *FY 2010 Plans:* - Complete evaluation of client-side controller software in laboratory environment. - Develop client-side laboratory-scale software and server-side virtual-machine based automated recovery. - Harden and evaluate client-side controller code for field-deployable operations.				
Security-Aware Systems	13.680	10.088	11.225	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(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). (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 with little or no human assistance. The effort will leverage advances in information assurance research programs to 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				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

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.

(U) The Scalable Cryptographic Key Management effort seeks to develop a key management and key distribution system with an overall overhead equal to or less than today's key management systems, while servicing thousands--or tens of thousands--of devices. The lack of a scalable key management and distribution system is the fundamental hurdle to the widespread deployment of secure radios and encryption devices to individual desktops. This effort will leverage changes in underlying technology and reduced costs for these new technologies to produce applications that will transition to the Services or via the commercial sector ranging from secure hand-held radios for tactical use to desktop level encryption devices for more secure networks.

FY 2008 Accomplishments:
- Developed techniques to collaboratively diagnose and respond to problems (e.g., attacks or failures that threaten a mission) in groups of military systems.
- Developed techniques to summarize security policy and status so the descriptions produced by the AC program can be understood without omitting critical details.
- Developed static and dynamic source code analysis techniques (e.g., data and control-flow-based techniques, model-checking, strong typing) to relate software module structures and runtime state with the representation of security properties/configurations.
- Demonstrated self-explanation techniques in which systems explain their critical security properties and status in a manner that is understandable to a variety of managing software components and human operators.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Developed additional general strategies to automatically immunize systems against new attacks and preempt insider attacks; enabling anomaly detection, combining and correlating information from system layers, and using direct user challenges. *FY 2009 Plans:* - Develop, test and validate regimes to assess the protection mechanisms of security products, and certify protection to quantifiable levels based on a scientific rationale. - Develop measures to quantitatively characterize various dimensions of security (availability, integrity, confidentiality, authentication, and non-repudiation), fault tolerance, and intrusion tolerance, and demonstrate the theory's relevance by applying it to a realistic exemplar system. - Tailor an exemplar self-regenerative system representative of a military application, thereby demonstrating the protective value to the warfighter. - Conceptualize a new computer workstation architecture that enables both formal proof and exhaustive validation of critical information and program separation properties. *FY 2010 Plans:* - Demonstrate a prototype exemplar self-regenerative system representative of a military application. - Mature, evaluate and transition technologies enabling development of an enterprise network that rapidly identifies, localizes and suppresses attacks and accidental faults automatically, and provides an early warning system that predicts these events. - Develop the architecture to enable a reliable key management system that will issue, revoke, and change the key for 10,000+ users. - Initiate fabrication of affordable key management system components.				
Control Plane (U) The Control Plane program improved end-to-end network performance between the Continental United States (CONUS) operating base and forward deployed tactical units. Control Plane developed the ability for individual hosts (end-points) to learn essential characteristics about the network, allowing the hosts to shape the network and network traffic to optimize network loading, prioritize traffic, and create communities	5.296	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
of interest. Under Control Plane, when multiple network paths are available, hosts are able to choose the best path/community or simultaneously transmit over multiple paths/communities. *FY 2008 Accomplishments:* - Developed and demonstrated the ability of individual hosts (end-points) to learn essential characteristics about the network path between themselves and their transition partners through network query protocols. - Investigated authentication protocols for secure transmission of network performance information. - Developed and demonstrated the ability of hosts to learn about more than one possible transmission path, other hosts' abilities and purpose, and form communities of interest which suits their collective needs best. - Developed and demonstrated the ability of hosts to simultaneously use multiple network paths for the same data transmission with the same partner, increasing communications speed and reliability. - Conducted demonstrations in operationally relevant environments.				
Control-Based Mobile Ad-Hoc Networks (CBMANET) (U) The Control-Based Mobile Ad-Hoc Networks (CBMANET) program is developing an adaptive networking capability that dramatically improves performance and reduces life-threatening communication failures in complex communication networks. In order to develop this new capability, the initial focus is on tactical mobile ad-hoc networks (MANETs) that are inadequately supported with commercial technology. Conventional MANETs are composed of interdependent nodes based on interdependent system layers. Each MANET node exposes tens to hundreds of configurable parameters that must be continuously adapted due to variable tactical factors such as mission profile, phase, force structure, enemy activity, and environmental conditions. The complexity of this high-dimensional, adaptive, constrained, distributed network configuration problem is overwhelming to human operators and designers and has root causes in the historically wire-line-oriented networking paradigms. This program will take on the ambitious goal of researching a novel protocol stack that supports integrated optimization and control of all network layers simultaneously. Key technical challenges include scalable design, stability, and convergence. These challenges are particularly difficult in a distributed setting with partial and uncertain information, high communications overhead, and high probability of link failure. To address this problem,	8.060	4.200	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
the CBMANET program will exploit 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 2008 Accomplishments:* - Designed appropriate interfaces between the CBMANET network stacks and the physical radios in support of cross-layer optimization. - Integrated the novel network architectures with physical radios and executed field experiments. - Demonstrated and evaluated CBMANET technologies in realistic DoD scenarios using modeling and simulation. - Began conducting a series of field demonstrations in challenging tactical environments, using tactically relevant radios. *FY 2009 Plans:* - Complete development and integration into military radio systems. - Execute final experiments and military demonstrations. - Transition activities to the Services.				
Code Characterization* *Formerly Defense Autonomous Systems. (U) The Code Characterization program will develop cyber forensic techniques to characterize, analyze and identify malicious code. Today malicious computer code is found through its effects and isolation after infection. Current detection, analysis, and corrective software requires an intensive, manual process that is always conducted afterwards. This program will develop breakthrough abilities in visualization, threat identification analysis and threat mitigation analysis to enable positive identification of malcode sub-structures. By using cross-utilization and cross-domain analysis using these baseline malcode sub-structures, this program will allow for the automatic discovery, identification, and characterization of any future variants of previously unknown malicious code in computing systems.	.000	3.750	8.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Investigate innovative methods of integrating detection techniques to quickly identify malicious code delivered through various file types. - Develop automatic techniques to rapidly and interactively reconstruct (encrypted and non-encrypted) meta data to assist in the analysis of malicious code, or non-white listed software archives. *FY 2010 Plans:* - Develop techniques and algorithms to enable the characterization of future malicious code variants based on analyzed malcode substructures. - Initiate integration of automatic discovery, identification, analysis, and prediction algorithms. - Establish red team to test the malicious code detection techniques. - 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.				
Geo-Steganography (U) The Geo-Steganography program will develop techniques for embedding additional information in a wide variety of digital file types in a manner that does not disturb the normal use of the file. This technology will enable tactical end users to add private information to normal digital communication channels, permitting privacy in a multicast, multiuser environment (for example coalition operations). The advantage of steganography is the ability to selectively expose additional private information to only a subset of end recipients within the context of ongoing normal message traffic. This can be accomplished in a way that minimally disturbs the usual file traffic over the channel. *FY 2010 Plans:* - Develop effective and transparent CONOPS for the use of steganography in operational settings as the basis for technology development and deployment. - Determine the most effective steganography techniques for tactical field use, considering document types, bandwidth impact, and ease of use.	.000	.000	5.000	
DARPA Future Information Assurance Initiatives	2.250	.000	.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification				DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The DARPA Future Information Assurance Initiatives identified promising technologies to enable remote command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) warfighting. Included in this initiative was the development of secure, efficient network protocols to exploit tomorrows network-centric technologies such as networked weapons platforms, mobile ad-hoc networks, and end-to-end collaboration (vice client-server paradigm). *FY 2008 Accomplishments:* - Developed a family of distributed, autonomous security devices to deal with asymmetric traffic on wide area networks. - Developed a secure, efficient network routing protocol for tomorrow's weapon, logistic, and command and control requirements. - Developed a wireless protocol that securely provides location, authentication, and communications in a practical manner. - Investigated new approaches to network security that scale with increased data rates and address spaces of future networks.				
Content Distribution (U) This program seeks to provide information to commanders and soldiers before they need it by anticipating their needs. Current systems (e.g., file caches, peer-to-peer networks or Akamai-like systems) watch what users' request and react by either moving data or shifting users to other data stores. These techniques neither move the data beforehand nor work efficiently in bandwidth constrained military environments. The Content Distribution program will combine content retrieval with geographic location aware content "pushing" that predicts what information deployed commanders will need and moves that data from one content network (e.g., in CONUS) to a deployed content retrieval network. The technology developed will provide content to deployed soldiers who are not in command posts by integrating the new content distribution system with the Disruption Tolerant Network (DTN) technology. This will allow the Defense Department to exploit network knowledge and signaling to push information during low network usage periods and reduce overall network loading, providing pre-positioned information so that commanders have the information they need before they need it. This program will also seek to decrease	.000	.000	4.750	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
overall data network (e.g., TCP/UDP/IP protocol based networks) loading by accurately predicting the content users will likely request based on past activity. *FY 2010 Plans:* - Develop a scalable architecture for efficiently publishing metadata on a distributed content network. - Develop network and routing discovery software that pinpoints routing and communications' bottlenecks. - Develop efficient algorithms to encode information to minimize network loading.				
High-Speed Optical Correlator for Next Generation Networks (U) The High-Speed Optical Correlator for Next Generation Networks program will investigate key technical areas of a revolutionary, high-speed optical correlator for next generation networks. As the core network data rates of fiber telecommunications increase, existing electronic content processors are challenged in terms of complexity and power consumption. Through the use of a novel optical-based digital pattern matching architecture, and using standard telecommunications components, this program will develop a scalable system that, together with electronic processing, will monitor, secure and assist next generation, very high data rate telecommunication networks (>100 Gbit/s). Successful implementation of this technology will allow existing slower speed, electronic processors to be used for secondary and more complex data processing. This combination of optical and electronic components will allow us to analyze a larger portion of the network traffic than is currently achieved. The useful life of existing electronic processing technology will also be significantly extended, in its role as a post-processor on the pre-sifted data. *FY 2010 Plans:* - Develop optical-based digital pattern matching architecture and complete the initial design for building the device. - Test critical sub-components to ensure their practicality. - Develop metrics for evaluating hardware components and system effectiveness. - Initiate development of high-speed optical correlator technology. - Complete design for a 1 Gbps prototype.	.000	.000	4.872	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Millicomputing (U) The Millicomputing program seeks an innovative approach to low-power computing that is anticipated to reduce power consumption by at least fifty percent. Given the increasing quantity of computing devices in military, government, and corporate environments coupled with expensive and uncertain energy resources, there is an urgent need to develop revolutionary technologies that greatly reduce energy use and cost in modern computing systems. The Millicomputing program will drastically reduce power consumption while maintaining high-grade computing performance by matching the computational platform to the user's needs; exploiting concurrency inherent in instruction sets, processes, and applications; and improving resource utilization across the computational platform. *FY 2010 Plans:* - Design and develop computational platform and system design architecture. - Develop millicomputing proof-of-principle testbed. - Initiate develop of prototype system.	.000	.000	4.000	
Trusted, Uncompromised Semiconductor Technology (TrUST) (U) The TrUST program was funded in FY 2008 under PE 0602716E, Project ELT-01. The TrUST program will address in Integrated Circuits (ICs) 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. The follow on effort will seek to discover an understanding of the function of an integrated circuit (IC) which is specified, designed and fabricated by someone untrusted; as is the case when using offshore resources. An example of such an integrated circuit would be a commercial off-the-shelf (COTS) application specific IC (ASIC) or COTS field programmable gate array (FPGA). While the COTS ASIC case is important, the COTS FPGA case is dominant, pervasive, and critical. *FY 2009 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 10^6 transistors in 240 hours.	.000	21.186	33.538	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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 Application Specific Integrated Circuits (ASICs) and Field Programmable Gate Arrays (FPGAs) for a design of 10^6 transistors in 240 hours. - Continue to refine and expand tools for FPGA verification and extend the number of FPGA families that they target for a design of 10^6 transistors in 240 hours. - Protect FPGAs from unauthorized substitutions by improving and empirically verify 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. - Protect FPGAs from unauthorized substitutions the program 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.				
National Repository of Digital Forensic Intelligence (U) This effort focused on the goal of the National Repository of Digital Forensic Intelligence. *FY 2009 Plans:* - Pursue efforts relating to the National Repository of Digital Forensic Intelligence.	.000	1.200	.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	PE 0602303E INFORMATION & COMMUNICATIONS TECHNOLOGY	IT-03

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Document Analysis and Exploitation *FY 2009 Plans:* - Conduct research in document analysis and exploitation.	.000	1.600	.000	
Intelligent Remote Sensing for Urban Warfare *FY 2009 Plans:* - Conduct research in remote sensing for urban warfare.	.000	2.400	.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, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification									DATE: May 2009	
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research				R-1 ITEM NOMENCLATURE PE 0602303E INFORMATION & COMMUNICATIONS TECHNOLOGY					PROJECT NUMBER IT-04	
COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
IT-04: LANGUAGE TRANSLATION	66.130	75.019	72.171						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 2008	FY 2009	FY 2010	FY 2011
Spoken Language Communication and Translation System for Tactical Use (TRANSTAC)	11.064	11.533	7.738	
(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 language tool that will meet the military's language translation needs. TRANSTAC is currently focusing on key languages of the Middle East region. *FY 2008 Accomplishments:* - Performed additional mission needs analysis and aggressive language data collection.				

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APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	R-1 ITEM NOMENCLATURE PE 0602303E INFORMATION & COMMUNICATIONS TECHNOLOGY			PROJECT NUMBER IT-04

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Developed new two-way translation software technologies for insertion into, and enhancement of, the two-way Iraqi systems. - Developed tools for rapid deployment of new languages and dialects. - Enhanced recognition and translation performance with a particular emphasis on a military lexicon for Iraqi Arabic. - Developed smaller form-factor prototypes to facilitate mobile use (towards eyes-free, hands-free) translation systems. - Increased robustness of the prototypes to address the issue of noisy environments. *FY 2009 Plans:* - Update/enhance the experimental systems in the field. - Continue mission needs analysis and aggressive language data collection. - Develop two-way translation systems in other languages that will enable the user to not only translate words, but also communicate and carry on limited conversation. - Develop context management translation techniques. *FY 2010 Plans:* - Continue to 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 (Dari and Pashto).				
Global Autonomous Language Exploitation (GALE) (U) The Global Autonomous Language Exploitation (GALE) program will develop and integrate technology to enable automated transcription and translation of foreign speech and text along with content summarization. GALE 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	46.935	46.396	40.015	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
translation accuracy by exploiting context and other clues. GALE will address unstructured speech such as talk show conversations and chat room communications, developing timely, succinct reports and alerts for commanders and warfighters. *FY 2008 Accomplishments:* - Developed methods to optimize the parameters of speech-to-text acoustic models such that transcription errors are minimized. - Developed discriminative training algorithms to optimize word alignment and translation quality. - Implemented an integrated search of speech-to-text transcription and machine translation. - Integrated metadata extraction into the speech-to-text components. - Evaluated translation and distillation technologies. - Incorporated syntactic analysis of the target language (English) with machine translation algorithms to improve translation fluency. - Transitioned preliminary technologies developed by the GALE program into high-impact military systems and intelligence operations centers. *FY 2009 Plans:* - Incorporate syntactic analysis of the source languages (Arabic and Chinese) and develop more accurate word alignments between source and target languages. - Perform 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. - Incorporate predicate-argument analysis to enhance machine translation and summarization. - Develop a new distillation algorithm to extract the 5 W’s (who, what, where, when, and why) for given documents and methodologies to evaluate distillation algorithms. - Continue to transition the GALE technologies, as available, into high-impact military systems and intelligence operations centers. *FY 2010 Plans:* - Develop methods for porting technology into new languages.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	R-1 ITEM NOMENCLATURE PE 0602303E INFORMATION & COMMUNICATIONS TECHNOLOGY	PROJECT NUMBER IT-04

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Complete the architecture for a summarization system that incorporates adaptive filtering, focused summarization, information extraction, contradiction detection, and user modeling. - 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.				
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. *FY 2008 Accomplishments:* - Improved methods for document segmentation (e.g., title, address box, columns, lists, embedded picture/diagram/caption, annotation, signature block, etc.). - Improved script (e.g., Roman vs. Cyrillic) and language (e.g., Farsi vs. Arabic) identification.	8.131	12.414	16.222	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Developed algorithms for document type identification (e.g., letter, ledger, annotated map, newspaper, etc.). - Developed means to discriminate and separate handwriting from printed regions and improved OCR/ OHR technologies. - Developed the means of interpreting different regions within a document, such as extracting information from an address field or the axes of a table. *FY 2009 Plans:* - Develop improved algorithms for document type identification (e.g., letter, ledger, annotated map, newspaper, etc.); to discriminate and separate handwriting from printed regions; and to improve OCR/ OHR technologies. - Create better means of interpreting different regions within a document such as extracting information from an address field or the axes of a table. - Develop algorithms to predict the syntactic structure and propositional content of text, and for recognizing and transcribing hand-written text. - 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. - Enable 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.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Extend language independent technology to languages also using Arabic script - 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 Plans:* - Improve the robustness of automatic speech transcription and translation algorithms in adverse environments (noise, distortion, reverberation, and competing speech signals). - Evaluate the relative benefits (performance versus computational requirements) of noise suppression and speech exploitation based on a single microphone versus using multi-microphone arrays. - Assess 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, and develop improved methods where required. *FY 2010 Plans:* - Continue to improve the robustness of automatic speech transcription and translation algorithms in adverse environments (those with noise, distortion, reverberation, and/or competing speech signals). - Continue to develop noise suppression and speech exploitation based on a single microphone versus using multi-microphone arrays. - Refine new speech processing techniques for noisy environments, including echo suppression, speech activity detection, language identification, speaker identification and keyword spotting.	.000	4.676	8.196	

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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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	157.897	144.869	142.840						Continuing	Continuing
COG-01: COGNITIVE SYSTEMS COMPUTING FOUNDATIONS	2.308	.000	.000						Continuing	Continuing
COG-02: COGNITIVE COMPUTING	88.331	88.392	98.429						Continuing	Continuing
COG-03: COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES	67.258	56.477	44.411						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) Military command, control, communications, and intelligence/information systems must support warfighters in 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 nor with the capability 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 support capability, as well as 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.

(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.

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(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.

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	174.680	145.262	135.671	
Current BES/President's Budget	157.897	144.869	142.840	
Total Adjustments	-16.783	-.393	7.169	
Congressional Program Reductions	.000	-.393		
Congressional Rescissions	-2.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	-10.000	.000		
SBIR/STTR Transfer	-4.783	.000		
TotalOtherAdjustments			7.169	

Change Summary Explanation

FY 2008
Decrease reflects Section 8042 rescission, the AFRICOM reprogramming, and the SBIR/STTR transfer.

FY 2009
Decrease reflects the Section 8101 Economic Assumptions.

FY 2010
Increase reflects minor repricing of cognitive computing systems programs, particularly in the area of software/algorithm development.

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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 NUMBER** COG-01	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
COG-01: COGNITIVE SYSTEMS COMPUTING FOUNDATIONS	2.308	.000	.000						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Cognitive Systems Computing Foundations project made fundamental advances in our understanding of and ability to create more intelligent information and computing systems. New foundational hardware architectures and software methods to facilitate learning and inference capabilities were created that are crucial to intelligent computing. These new computing foundations will help us move far beyond today's standard Von Neumann computing model. Transition goals include next-generation network-centric systems and platform-specific information collection and processing systems. This project will complete with FY 2008 funding and on-going efforts will continue in other Program Elements.

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Self-Regenerative Systems (SRS) (U) The Self-Regenerative Systems (SRS) program designed, developed, demonstrated and validated architectures, tools, and techniques for fielding systems capable of adapting to novel threats, unanticipated workloads and evolving system configurations. The technology developed under this program employed innovative techniques including biologically-inspired diversity, cognitive immunity and healing, granular and scalable redundancy, and higher-level functions such as reasoning, reflection and learning. These technologies will make critical future information systems more robust, survivable and trustworthy. The SRS program also developed technologies to mitigate the insider threat. (U) SRS-enabled systems are able to reconstitute their full functional and performance capabilities after experiencing an accidental component failure, software error, or even an intentional cyber-attack. SRS systems show a positive trend in reliability, exceed initial operating capability and approach a theoretical optimal performance level over long time intervals. They also maintain robustness and trustworthiness attributes even with growth and evolution in functionality and performance.	2.308	.000	.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**		**DATE:** May 2009		
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	**R-1 ITEM NOMENCLATURE** PE 0602304E COGNITIVE COMPUTING SYSTEMS		**PROJECT NUMBER** COG-01	

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Developed additional general strategies and techniques to automatically immunize systems against new attacks and preempt insider attacks; combining and correlating information from system layers using direct user challenges.				

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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
COG-02: COGNITIVE COMPUTING	88.331	88.392	98.429						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 2008	FY 2009	FY 2010	FY 2011
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 the Increased Command and Control Effectiveness (ICE) program (PE 0603760E, Project CCC-01) prior to transition into Command Operations. (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 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.	34.114	27.344	26.275	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(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 2008 Accomplishments:* - Developed, demonstrated, and evaluated core physical awareness, cyber-awareness, multimodal dialogue, machine learning, and representation and reasoning technologies to support cognitive assistant executive functions. - Formulated an approach for receiving user guidance and translating it into the precise machine language necessary for both implementation and verification of user purpose and intent. - Demonstrated the utility of PAL technologies for the Army Knowledge Online's Company Command online community. - Optimized PAL technology to provide maximum benefit to operational users. - Demonstrated PAL technologies on data from a number of operational military systems and used the results of these demonstrations as lessons-learned for integration activities being conducted in military environments. (See PE 0603760E, Project CCC-01 for additional details). *FY 2009 Plans:* - Develop 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. - Develop the ability for an integrated cognitive system such as PAL to examine its own behavior and learn from that experience. - Extend, improve, and optimize 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.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Integrate dialogue system with semantically-enabled search capabilities to enable intelligent, user-defined Web search routines. - Create the ability for cognitive systems to exchange locally-learned knowledge.				
Integrated Learning (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 2008 Accomplishments:* - Enhanced integrated learning systems so the systems form explicit learning goals, make plans to achieve these goals, create hypotheses about learned knowledge where appropriate, and resolve sources of uncertainty in learned knowledge where it exists. - Expanded systems so they combine different types of knowledge and reasoning, based on the situation and information that is available. - Modified existing algorithms so they track uncertainty about information. - Evaluated systems by having them learn expanded/full processes and procedures for air control order planning and military medical evacuation planning. *FY 2009 Plans:* - Modify the integrated learning systems so they can incorporate new software components dynamically and utilize the new capabilities while learning.	20.011	17.160	15.068	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Create 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. - Create control algorithms that reason about the costs/benefits of resolving a particular conflict and direct system performance accordingly. - Expand the scope of the problems being learned so the systems learn multi-user task models. - Evaluate systems by having them compete against expert humans. *FY 2010 Plans:* - 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. - Field test integrated learning systems within operational military environments. - Evaluate systems by having them compete against expert humans.				
Bootstrapped Learning (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.	6.673	9.081	8.650	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Produced a prototype end-to-end system capable of bootstrapped learning, integrating different types of learning, input modalities, and repeatedly building on prior learning. - Developed a complete electronic curriculum for three domains, including prerequisite knowledge, teaching algorithms, as well as curriculum development tools. - Demonstrated the ability to learn a curriculum composed of at least three related lessons via at least three different interaction modalities and at least two different learning processes. *FY 2009 Plans:* - Demonstrate a single system capable of being instructed to perform in three diverse domains. - Demonstrate the ability of a system to repeatedly acquire new knowledge that drives future learning and cumulatively adds to the system's knowledge. - Validate that 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 instructable situational awareness.				
Machine Reading and Reasoning Technology* *Formerly Knowledge Representation and Reasoning Technology. (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 these 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). DoD systems sense, capture, and store information in the form of text, audio,	2.346	7.807	12.450	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

imagery, and video. Therefore, advanced machine reasoning capabilities must extract knowledge from, and reason about, all types of multimedia data. This research will explore new computational models to enable command and control systems to use conceptual representations to perform perception-based cognition and to assist the commander in understanding and analyzing complex battlefield scenarios. Perception-based cognition and visual-spatial reasoning are of particular interest.

(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 2008 Accomplishments:
- Demonstrated novel methods for acquiring new knowledge directly from processing natural language text.
- Developed a proof-of-concept machine reading prototype that learned by reading small focused texts, encoded knowledge from these texts, and answered narrow queries that required deep semantic representations.

FY 2009 Plans:
- Extend 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.
- Produce 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 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Develop knowledge representation and reasoning capabilities to support simple temporal reasoning using ordered relationships in text. - Demonstrate ability of machine reading systems to extract knowledge from texts that employ varied writing styles and require contextualization for proper interpretation. - Design new cognitive architectures that combine new ideas in visual concept learning, analysis, and imagination with traditional machine reasoning techniques. - Conduct initial development of visual processing modules that provide more intuitive, common sense, human-like and efficient visual reasoning.				
Foundational Learning Technology (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. 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. (U) The Foundational Learning Technology program will develop techniques that enable cognitive systems to reason about their own reasoning and, hence, learn a self model. This capability will allow the system to explain itself during learning, for example, by constructing memory traces of how reasoning occurred. Meta-level monitoring of traces then produces an explanation of why reasoning might fail, and introspection enables the construction of an explicit learning strategy driven by this self-model. (U) The Cortical Algorithm program will model the sub-symbolic “instruction set” of the brain. It will create a new, non-symbolic representation/reasoning paradigm based upon a universal algorithm that starts with zero knowledge and recursively builds upon learned knowledge through self-direction. This new paradigm would enable systems to learn through immersion, representing structure latent in the environment and	14.603	10.000	14.196	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
modeling its own behavior on the observed behavior of other agents in the world, resulting in much greater autonomy and reducing the need for human interaction. *FY 2008 Accomplishments:* - Demonstrated the ability of a cognitive agent to learn, combine, and restructure knowledge in multiple domains and applied this to solve novel problems in those domains. - Demonstrated the ability of a cognitive agent to generalize knowledge from particular domains and discovered how to apply it to a problem in a new domain. - Demonstrated the ability of a cognitive agent to synthesize knowledge and skills acquired from multiple domains, applied them effectively to problems in new domains, and demonstrated the ability to propose novel problem solution methods when specified resources are unavailable. *FY 2009 Plans:* - Demonstrate 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. - Conceptualize and propose algorithms that can take unorganized numeric inputs and, through interaction, “see” that these inputs represent some structured universe that obeys structured laws. *FY 2010 Plans:* - 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. - Create a self-explaining module that helps debug agent programs by mapping anomaly symptoms to causal faults. - Build infrastructure to support reflective records of decision-making tied to behavior traces.				
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	10.584	15.000	16.490	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 robust navigation and locomotion, 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. Efforts are being made to develop learning and reasoning technologies to address specific concerns in both wheeled and legged robotic systems. There is also interest in anthropomorphic humanoid robots that can leverage the worldwide infrastructure built for humans (e.g., occupy seats in transport vehicles, climb stairs, grasp knobs/handles and open doors, etc.) and free our soldiers from dangerous tasks such as search and rescue missions. (U) Robust Robotics is developing techniques for robots to perform in dynamic environments by improving robotic vision and scene understanding, including the capability to predict the future location and even the intent of moving objects. U.S. National security will require future autonomous systems that achieve a much higher autonomy level when performing complex tasks. Robust Robotics is developing techniques that will enable robotic agents to achieve effective levels of autonomous reasoning and manipulation whether humans are present or not. 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. Robust Robotics is also addressing the need for future U.S. unmanned vehicles to perform reliably in the absence of GPS, which can be achieved by recognition of local features, including man-made and natural features, for navigation in diverse environments. *FY 2008 Accomplishments:* - Created new learning algorithms that use dynamic gaits to enable legged laboratory robots (small scale versions of operational size platforms) to run over uneven terrain. - Evaluated new learning algorithms on a series of different terrain settings in a competitive fashion. - Transferred the best performing navigation methods learned on a small-scale vehicle to the large robotic vehicle, Crusher, to operate at increased speeds in complex environments. - Funded prizes and support for the DARPA Urban Challenge.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Create new and modify existing learning algorithms to enable legged laboratory robots (small scale versions of operational sized platforms) to run over terrain at speeds proportional to humans. - Evaluate the new learning algorithms on a series of different terrain settings in a competitive fashion. - Port learning locomotion algorithms to larger scale vehicles to increase mobility of larger scale robots. - Create learning locomotion toolkits that will 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. - Integrate motion understanding and reasoning for dynamic environments on a Government furnished platform and demonstrate travel at 1 mph with five independent movers over 100 meters of crowded urban terrain. - 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. - Develop recognition-based navigation techniques for the case where all data needed for recognition-based navigation (e.g., landmarks, topography) will either be pre-loaded (i.e., organic) or obtained using on-board sensors, and the vehicle/system will not receive any information from external sources.				
Biomimetic Computing* *Previously this was part of Foundational Learning Technology. (U) Biomimetic Computing’s goal is to develop the critical technologies necessary for the realization of a Conscious Artifact comprised of biologically derived simulations of the brain embodied in a mechanical	.000	2.000	5.300	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 Plans:* - Create a special purpose processor and associated assembly language to enable systems to have one million neuronal processing units. *FY 2010 Plans:* - Develop the capability to simulate a system of one million thalamocortical neurons with spike time dependent plasticity.				

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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 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	67.258	56.477	44.411						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 (e.g., frequency) 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 2008	FY 2009	FY 2010	FY 2011
Collaborative Cognition (U) The Collaborative Cognition program is aimed at developing technologies that enable individual cognitive agents to work together as a team to provide cooperative support to warfighters in complex military situations. Such situations typically require multiple coordinated tasks that involve information sharing and cooperative efforts. The Collaborative Cognition program will foster the design and implementation of collaborative software agents that operate in dynamic environments, and include both software agents and people. Applications include collaborative surveillance and reconnaissance, logistics re-planning and decision support for unanticipated operational changes, situational analysis and prediction tools, and warfighter/commander decision aids. The technology will also allow software agents to cope	28.800	17.000	10.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
with limited and/or noisy sensor information, limited communication capabilities, changing and unforeseen environments, other agents, and limited a priori knowledge of each others capabilities. • The Coordination Decision-Support Assistants (COORDINATORs) effort will develop cognitive software coordination managers that provide support to fielded tactical teams. The coordination managers will help fielded units adapt their mission plans in response to unanticipated changes in the mission by tracking personnel, resources, and situational changes, and proposing and evaluating options (adjustments to task timings, changes to task assignments and selection from pre-planned contingencies). This will enable fielded units to respond faster and more accurately to the dynamically changing battlefield situation, requiring far fewer personnel in the re-planning process. COORDINATORs is a distributed technology where a single COORDINATOR will be partnered with each tactical unit or team, and will be able to collaborate and coordinate with other tactical units to optimize needed mission changes. • 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. The ASSIST effort will develop an integrated system using advanced technologies for processing, digitizing and analyzing information captured and collected by soldier-worn 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. *FY 2008 Accomplishments:* Coordination Decision-Support Assistants (COORDINATORs) - Modified coordination algorithms so they can reason about the physical geolocation of units and coordinate changes in unit location.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Modified coordination algorithms so they can operate effectively in network situations where latency may impact communications as it does in field settings. - Developed a coordination autonomy controller that enables a COORDINATOR system to interact intelligently with its human user, generating desired options and waiting for appropriate periods of time for the human to respond. - Developed a change evaluation module that couples the COORDINATOR technology to GPS units so the system automatically knows the location of a given unit. - Developed a basic representation for military decision making policies and procedures so the COORDINATORs follow procedures, and decisions are made at the proper levels. - Evaluated COORDINATORs technologies in a field setting. Advanced Soldier Sensor Information System and Technology (ASSIST) - Demonstrated an automated, sensor-cued collection system for ground patrols and developed interface with the ASSIST-developed Tactical Ground Reporting System (TIGR). - Developed a software system to interpret and automatically index soldier-centric activities, events, scenes, and objects. - Developed analysis tools for the collected data. - Prototyped a two-way capability for alerting patrols in the field. *FY 2009 Plans:* Coordination Decision-Support Assistants (COORDINATORs) - Develop a full and general purpose representation for military decision making policies and procedures so the COORDINATORs know when information must be propagated, and to whom, and reason about the full spectrum of decision authority. - Add learning algorithms to the change evaluation module so it can learn to anticipate problems before they arise. - Add resources and models of resources to the plan representation language and modify the coordination algorithms to coordinate over resources, (e.g., troop transportation vehicles). - Integrate COORDINATORs technologies with SOFTools, a planning system used by U.S. Special Operations Command.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Evaluate COORDINATORs in a field setting. Advanced Soldier Sensor Information System and Technology (ASSIST) - Establish a Memorandum of Agreement with the U.S. Army to delineate the transition of the TIGR system to a program of record, as well as the schedule for transition. - Demonstrate real-time reporting using on-soldier sensors and an intuitive information push/pull user interface. - Address the technical challenges associated with providing ASSIST as a real-time capability for the dismounted soldier in the field. - Develop and demonstrate a real-time variant for use by dismounted soldiers, with enhancements that include video feeds from airborne platforms. - Develop key technological components that enable in-field data sharing and retrieval on a wearable computing/sensor platform. - Demonstrate eyes-free, hands-free, attention-free collection of key events and experiences for reporting. - Demonstrate tools for analyzing blue-force and red-force trends and patterns. - 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. - Integrate advanced multimodal sensor event and object extraction techniques into advanced systems and evaluate the enhanced capabilities. *FY 2010 Plans:* Advanced Soldier Sensor Information System and Technology (ASSIST) - Develop the means for efficient transfer of ASSIST information across Army Tactical Networks. - 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. - Automate the extraction of relevant portions of feeds for indexing into the TIGR database.				
Cognitive Networking	28.058	25.263	18.909	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 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. Research in this area will create a radical new design for distributed computers, device networks, and the software to manage these systems. Cognitive information processing will be used to optimize networked communications based on current conditions, past experience and high-level user guidance. Robotic technologies will be employed where appropriate, for example, to maintain connectivity with small units and individual dismounts on the move. 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. This technology enables the automatic adaptation of protocols to the operational environment. SAPIENT will exploit attributes of human cognition, such as learning and self-improvement, and apply them to the automated construction of network protocols. Key research challenges for the SAPIENT effort are the use of these cognitive attributes to dramatically reduce the effect of network impairments on applications while demonstrating a positive trend in this capability as new situations are encountered and learned. Desired capabilities include interoperable knowledge representations and rapid incorporation of new knowledge about applications, network conditions and building blocks from which new protocols can be constructed.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
• 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. 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. The BOSS effort will initially focus on modeling and simulation, resulting in hardware-independent executable specifications of waveforms in an interoperable format. Once the modeling and simulation is verified, the BOSS effort will develop a prototype demonstration for a selected RF platform, using and refining the hardware-independent executable specifications of the waveforms. Ultimately this effort will develop Software Communications Architecture (SCA)-compliant waveforms suitable for implementation on a tactical software radio system. *FY 2008 Accomplishments:* Situation-Aware Protocols in Edge Network Technologies (SAPIENT) - Integrated and enhanced prototypes and evaluated their performance. - Refined new knowledge representations appropriate for describing multiple link situations encountered in tactical military networks and for enabling machine response to these situations including automated learning of effective responses. - Researched and integrated new network and application sensors, and adaptation techniques into prototypes. - Refined protocol selection and composition strategies with integrated learning capability strategies.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Demonstrated SAPIENT capabilities in laboratory and experimental airborne venues. Local Area Network droids (LANdroids) - Developed control algorithms for LANdroids so they can self-configure, self-optimize, and self-heal. - Developed small robotic LANdroids platforms that meet basic requirements for size and capability. Brood of Spectrum Supremacy (BOSS) - Performed further testing and evaluation of RF-situational awareness algorithms. - Conducted in-depth assessment of candidate BOSS transition platform. *FY 2009 Plans:* Situation-Aware Protocols in Edge Network Technologies (SAPIENT) - Integrate and enhance prototypes and evaluate their performance. - Implement a functional cognitive learning system that facilitates real-time selection and composition of protocols. - Demonstrate an adaptive cognitive prototype in an urban environment using mobile, airborne, and stationary nodes. - Demonstrate prototypes using actual tactical link types. Local Area Network droids (LANdroids) - Evaluate a 10-node LANdroids network with respect to self-configuration, self-optimization and self-healing. - 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. - Harden the LANdroid robotic platform and reduce its weight.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Brood of Spectrum Supremacy (BOSS) - Refine capabilities of Software Communications Architecture (SCA)-compliant platforms, while working within the software-defined radio trade space. - Validate implementations for network understanding tasks using SCA-compliant platforms. *FY 2010 Plans:* Situation-Aware Protocols in Edge Network Technologies (SAPIENT) - Create an operating system kernel implementation of cognitive protocol management mechanisms. - Develop a Memorandum of Understanding with a Service transition partner. - Demonstrate cognitive networking capabilities in a Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) testbed. - Develop a database of network behaviors based on a long term installation at the C4ISR testbed. - Develop methods to resolve contention of multiple SAPIENT instances. 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. - Integrate LANdroids algorithms with hardened and lightened robotic platform. - Develop control algorithms for LANdroids that enable LANdroid modes (programmable objective functions, maximize power savings, and maximize throughput). - Develop control algorithms for LANdroids that enable system heterogeneity (systems consisting of multiple gateways, static relays, warfighter handheld relays, and non-relaying static and mobile radios). Brood of Spectrum Supremacy (BOSS) - Modify the design of an existing handheld radio to provide platform for BOSS algorithms. - Collect field data and implement algorithms in a fashion compatible with handheld/wearable radio platforms.				
Cloud Computing *Formerly Integrated Collective Systems	10.400	14.214	15.502	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 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, 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 2008 Accomplishments:* Digital Object Storage and Retrieval (DOSR)				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Extended the digital repository architecture to enable ubiquitous access from multiple devices while providing secure, effective, document sharing. - Developed a prototype repository system with military applicability that can facilitate an open, extensible, and vendor-independent architecture. - Researched and developed technologies to address issues of access control, security, and version tracking. Data Integration and Exploitation SystEm that Learns (DIESEL) - Reviewed the commercial technology baseline and described military needs and representative challenge problems. *FY 2009 Plans:* Digital Object Storage and Retrieval (DOSR) - Develop and refine concepts for the repository architecture. - Prototype subsystems that address access control and security in a networked environment and support a public/private key infrastructure (PKI) as a means of authentication. - Prototype subsystems that address the intelligent search and access of heterogeneous information. - Prototype subsystems that address intelligent pre-positioning of information based on user models and provenance to enhance availability and to support intermittently connected operations. Data Integration and Exploitation SystEm that Learns (DIESEL) - Demonstrate preliminary ideas for learning-based entity resolution, data source modeling, and schema mapping technologies. - Develop technology that observes warfighter information systems to learn system semantics. - Evaluate automated alignment and translation technology through tests with realistic military information systems and a variety of new data sources. *FY 2010 Plans:* Digital Object Storage and Retrieval (DOSR)				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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 for information search, access, and proactive distribution. - Demonstrate secure, geographically distributed and replicated storage with superior retrieval performance characteristics. Data Integration and Exploitation SystEm that Learns (DIESEL) - Develop ability to identify concepts (e.g., schema element names and types) present in new data sources but not already in data sources of an existing warfighter information system. - Demonstrate ability to surface new concepts from new data sources through semantically and syntactically well-formed input to existing warfighter information systems. - Evaluate automated data integration technology through tests with realistic military information systems and a variety of new data sources of increasing complexity.				

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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	64.127	56.139	40.587						Continuing	Continuing
BW-01: BIOLOGICAL WARFARE DEFENSE	64.127	56.139	40.587						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 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	72.101	66.291	55.398	
Current BES/President's Budget	64.127	56.139	40.587	
Total Adjustments	-7.974	-10.152	-14.811	
Congressional Program Reductions	.000	-10.152		
Congressional Rescissions	-6.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	.000	.000		
SBIR/STTR Transfer	-1.974	.000		
TotalOtherAdjustments			-14.811	

Change Summary Explanation

FY 2008

Decrease reflects Section 8042 rescission and the SBIR/STTR transfer.

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FY 2009
Decrease reflects the reduction for Section 8101 Economic Assumptions and a program element execution adjustment.

FY 2010
Decrease reflects draw down of biological warfare defense (BWD) efforts as programs transition directly to elements of the DoD (i.e., the Army, Defense Threat Reduction Agency) that have cognizance over Service BWD materials and systems, and reclassification of sensor development programs to protect the technological attributes of the systems.

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
BW-01: BIOLOGICAL WARFARE DEFENSE	64.127	56.139	40.587						Continuing	Continuing

A. Mission Description and Budget Item Justification

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Unconventional Therapeutics (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. This has led to several significant transitions, a separate thrust in Anthrax countermeasures, and most recently a program at Defense Threat Reduction Agency (DTRA) that directly capitalizes on previous DARPA investments. 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.	26.235	20.470	22.950	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(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 program is also developing an interactive and functional in vitro human immune system using tissue engineering. This “immune system” will be able to test the efficacy of vaccines against threat agents that, at the present time, can only be tested in animal models. This significantly decreases the time needed and increases the probability of success for biological warfare vaccine development. An additional focus 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. *FY 2008 Accomplishments:* - Demonstrated plant and bacteria platform with more than 1000-fold increase in vaccine protein manufacturing rate using performer-chosen agent. - Demonstrated fungus platform with a 10-fold increase in monoclonal protein manufacturing rate. - Expressed multiple monoclonal antibodies (mAbs) using 7 strains of new mushroom-specific condon algorithms. - Produced over one million pounds of biomass in 6.5 weeks and developed enhanced purification method for downstream processing. - Predicted historical failed therapeutics using only the artificial human immune system. - Demonstrated government and commercial collaboration by using the artificial human immune system to test vaccine candidates for human response. - Demonstrated fusogenic properties of antibodies. - Developed approaches for on-site battlefield synthesis of small molecule therapeutics, including antibiotics. - Merged molecular imprinting with organic nanoparticles to generate functional viral replicates.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Express 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). - Demonstrate plant platform capability to produce three million doses of DARPA-specified vaccines in twelve weeks with improved biochemistry metrics. - Demonstrate fungus platform capability to produce three million doses of DARPA-specified monoclonals in twelve weeks with improved biochemistry metrics to provide confidence prior to entering FDA trials. - Demonstrate mushroom platform capability to produce three million doses of DARPA-specified vaccine and/or monoclonals in twelve weeks with improved biochemistry metrics to provide confidence prior to entering FDA trials. - Demonstrate improved biochemistry metrics which include: protein solubility (greater than ninety-nine percent), fragmentation (less than 0.1 percent) and folding (greater than 99.9 percent) for both vaccine and monoclonal platforms. These are over and above the current FDA best of class, to provide confidence prior to entering FDA trials. - Demonstrate pathway to reduction of vaccine and/or monoclonal production cost per dose. - Ensure thirty percent mass efficiency from base components to final medication, and a flow-through rate of forty-five standard doses per hour of one medication and five standard doses per hour of each of the seven medications. - Create a controlled environment to monitor pathogen evolution in response to host specific interactions including vaccination. *FY 2010 Plans:* - Complete demonstration of 100-fold increase in manufacturing rate. Performers that are creating a vaccine platform will need to show a manufacturing rate greater than or equal to 100 doses per liter times number of weeks. Those that are developing a monoclonal platform technology must demonstrate a manufacturing rate greater than or equal to 2.5 doses/per liter times number of weeks. - Significantly reduce vaccine production costs to one dollar per dose and/or monoclonal production to ten dollars per dose.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Demonstrate proof of scale-up and platform flexibility through a live fire test. Each performer will produce 1,000 doses of vaccine and/or monoclonal at lab-scale cGMP against a DARPA-designated unknown agent in twelve weeks, including final manufacturing rate, biochemistry and cost metrics. - Demonstrate dose efficacy using animal models and DARPA's Rapid Vaccine Assessment (RVA) artificial human immune system. - Document contaminants, system development, and quality control to facilitate pre-investigational new drug meetings with FDA. - Integrate diverse species specific host cell responses to pathogens within a microenvironment circuit model. - Refine resolution of metamaterial lenses to pathogenic scales. - Develop laser refractive mechanism and sample target control device. - Identify a unified, coherent global strategy for addressing all remaining gaps in the Nation's biodefense capability. - Identify means to prevent infection by hardening host against infection, weakening the pathogen and preventing secondary infection. - Develop approaches for preventing death by converting deadly to non-lethal pathogens. - Develop techniques for including transient immunity by transplanting immunity from survivors, rapidly creating neutralizers and re-targeting immunity.				
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 includes the autonomous detection and self-cleaning of surfaces contaminated by an attack, and the safe neutralization of hazardous materials. This program will focus on the integrated thermal model of combatant in operational conditions and address the heat transfer coupling for better evaporative cooling. *FY 2008 Accomplishments:* - Optimized active textile cells for improved gas generation efficiency, lifetime, sporacidal ability, and cell reliability.	1.500	4.848	1.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Developed additives (surface active biocides, nutrients, microspheres) into a spray and spread coatable chemical agent resistant coating (CARC) resin to enhance biocidal effect at moderate humidity. - Developed atmospheric pressure cold plasma deposition processes to deposit biocidal materials that are 100 percent compatible with semiconductor devices and capable of killing spores. - Demonstrated process compatibility with high sensitivity electronic components and subsystems. - Demonstrated efficacy and durability after exposure to vaporous hydrogen peroxide, a currently planned active decontamination technique that complements the self-decontaminating surfaces capabilities. *FY 2009 Plans:* - Demonstrate biocidal efficacy of active textile cells on animal remains. - Field test the optimized self-decontaminating polyurethane based CARC on military vehicles at Dugway Proving Grounds using biological warfare simulants. *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 will develop 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 will be examined.	12.265	9.527	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Identified parameters that indicate presence of a viral infection before symptoms occur. - Developed algorithms that can predict illness from rhinovirus, respiratory syncytial virus and influenza B as well as other upper respiratory pathogens prior to onset of symptoms. - Identified candidate molecular markers to enable development of rapid diagnostic platform. - Developed preliminary model to describe host genomic response to rhino virus infection. - Continued to develop medical countermeasures that alleviate radiation exposure in experimental models. - Continued evaluation of non-invasive rapid biodosimeters that can be used to triage large populations in the event of a large radiological/nuclear event. - Completed evaluation of volatile organic compounds in the breath of explosive handlers. - Demonstrated Receiver Operating Curve (ROC) for detection of explosive handlers and bystanders. - Demonstrated reversible mechanical alterations in protein structure that yield a 2-fold change in affinity to biological, chemical and environmental agents. *FY 2009 Plans:* - Refine predictive model of impending illness to increase the probability of detection and reduce probability of false alarms. - Confirm predictive model of impending illness accuracy in large sample-size, warfighter relevant populations. - Evaluate potential diagnostic platforms for rapid identification of host molecular markers, which indicate viral infection prior to the onset of symptoms. - Develop proof of concept biosensors based on “best fit” of diagnostic platforms, predictive models, and host molecular marker studies. - Evaluate radiation technologies at the Armed Forces Radiobiology Research Institute (AFRRI) in a live fire test to identify best biodosimeters.				
Sensors (U) The Sensors program goal is to develop a unique set of biological warfare (BW) sensors that will greatly improve sensitivity and response time to bacteria, viruses and/or toxins.	11.627	10.000	16.637	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

(U) The Hyperadsorptive Atmospheric Sampling Technology (HAST) program will develop systems that permit exhaustive, accurate, and economical collection of atmospheric trace constituents to support chemical mapping of urban and military environments. The system, which integrates three technical components, will demonstrate materials, packaging, and extraction technologies that sample atmospheric impurities whose concentration ranges from 20 parts per trillion to 200 parts per million by volume from 100 liter-atmospheres of gas in less than five minutes. New methods to swiftly and economically identify and characterize mixtures of trace gases to support chemical mapping and reconnaissance will also be developed. These new methods will enable identification of chemical compounds for which library spectra are unavailable. HAST will collect chemical samples that will be utilized to generate chemical maps that enable tactical chemical awareness, strategic intelligence, and force protection.

FY 2008 Accomplishments:

Hyperadsorptive Atmospheric Sampling Technology (HAST)
- Developed new materials including metal organic framework structures and amorphous carbide-derived carbon lattices.
- Initiated new manufacturing methods derived from embossed rolled films and compact discs.

FY 2009 Plans:
- Develop prototype instrument to identify sort mixtures of up to 100 gases.
- Develop and test extraction methods.
- Integrate new materials with optimal packaging approaches.
- Measure probability of detection and probability of false positive for trace gas samples of hundreds of picomoles.

FY 2010 Plans:
- Optimize manufacturing technology at useful scales.
- Develop technologies and algorithms to identify pure gases without the use of spectral libraries.
- Extend analytical instrument sensitivity to tens of picomoles of up to 300 gases.
- Increase rate of analysis to thousands of samples per day.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	**R-1 ITEM NOMENCLATURE** PE 0602383E BIOLOGICAL WARFARE DEFENSE	**PROJECT NUMBER** BW-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop protocol for identification of unknown gases in micromole quantities without library spectra. - Integrate fundamental spectroscopic and quantum chemical analyses to identify unknown gases.				
Threat Agent Cloud Tactical Intercept Countermeasure (TACTIC) (U) The Threat Agent Cloud Tactical Intercept and Countermeasures (TACTIC) program will develop and demonstrate the capability to 1) rapidly detect, classify and identify an airborne chemical warfare agent/ biological warfare agent (CWA/BWA) battlefield threat at stand-off distances, and 2) use countermeasures to neutralize and/or precipitate the threat before it reaches the intended target. The TACTIC program will develop a prototype system having an integrated approach for the classification/identification (CI) and countermeasure (CM) of aerosolized CWA/BWA threat clouds. The TACTIC system prototype will be evaluated in a controlled breeze tunnel testing environments with variations in range, concentration and wind speed. Upon successful completion of the preliminary design and critical design reviews, a prototype system will be built to demonstrate an effective CI and CM systems capability in open air tests. A memorandum of agreement (MOA) is in place with the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD) for transitioning this capability to the Army. *FY 2008 Accomplishments:* - Completed Conceptual Design Review. - Began bench scale, drop tube, and chamber testing of the CI/CM against CWA/BWA aerosolized threat clouds. - Began modeling threat scenarios by the independent validation and verification (IV and V) team. - Evaluated the performers' systems' technology readiness level (TRL) following each technical review. - Completed Preliminary Design Review (PDR). *FY 2009 Plans:* - Commence Critical Design Review (CDR). - Complete and validate models of CI/CM subsystem performance for operationally realistic tests.	10.000	8.430	.000	
Mission-Adaptable Chemical Sensors (MACS)	2.000	2.864	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 will develop a sensor, based upon rotational spectroscopy of gases that will have superior capability in all categories; it will achieve the highest possible sensitivity in ppt for unambiguous detection of all chemical species. A preliminary blind test showed complete and unambiguous identification of an unknown sample containing multiple chemical species with a sampling time of one second and a false alarm probability below 0.001%. At present, the program 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 will focus on reduction of size and simplicity of function to achieve portability and simultaneous detection of a large number (hundreds) of species. The capabilities will far surpass all other current sensors. *FY 2008 Accomplishments:* - Constructed and demonstrated a fully-integrated, portable, prototype chemical sensor system able to identify more than 30 analytes correctly. *FY 2009 Plans:* - Identify users and particularize the MACS sensor for their objectives. - Extend the spectral reference library of analytes to hundreds to suit the different applications. - Automate the sensor to identify the chemical analytes within a sample using computer lookup. - Reduce sample analysis time to less than one minute.				
Biomedical Engineering Initiative *FY 2008 Accomplishments:* - Developed biosensors to identify blood-borne biomarkers of tissue trauma that convey information concerning injury severity and prognosis.	.500	.000	.000	

C. Other Program Funding Summary ($ in Millions)

N/A

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D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency **RDT&E Budget Item Justification**	**DATE:** May 2009
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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	260.219	352.924	276.075						Continuing	Continuing
TT-03: NAVAL WARFARE TECHNOLOGY	23.207	50.493	25.054						Continuing	Continuing
TT-04: ADVANCED LAND SYSTEMS TECHNOLOGY	53.415	65.891	36.494						Continuing	Continuing
TT-06: ADVANCED TACTICAL TECHNOLOGY	90.867	118.751	88.129						Continuing	Continuing
TT-07: AERONAUTICS TECHNOLOGY	37.067	48.201	50.066						Continuing	Continuing
TT-13: NETWORK CENTRIC ENABLING TECHNOLOGY	55.663	69.588	76.332						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.

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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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 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	335.967	371.481	355.591	
Current BES/President's Budget	260.219	352.924	276.075	
Total Adjustments	-75.748	-18.557	-79.516	
Congressional Program Reductions	.000	-30.957		
Congressional Rescissions	-23.000	.000		
Total Congressional Increases	.000	12.400		
Total Reprogrammings	-43.550	.000		
SBIR/STTR Transfer	-9.198	.000		
TotalOtherAdjustments			-79.516	

Congressional Increase Details ($ in Millions)

	FY 2008	FY 2009
Project: TT-03, **CEROS**	.000	10.000

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Congressional Increase Details ($ in Millions)	FY 2008	FY 2009
Project: TT-03, **SeaCatcher UAS Launch and Recovery System**	.000	1.600
Project: TT-04, **Explosively Formed Projectile Iron Curtain**	.000	.800

Change Summary Explanation

FY 2008
Decrease reflects Section 8042 rescission, the OSD O&M and AFRICOM reprogrammings, and the SBIR/STTR transfer.

FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and execution delays, offset by congressional increases identified above.

FY 2010
Decrease reflects the transition and completion of several urban operations efforts in the Advanced Land Systems Project (TT-04) as well as completion of Aeronautics Technologies programs in Project TT-07.

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TT-03: NAVAL WARFARE TECHNOLOGY	23.207	50.493	25.054						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 2008	FY 2009	FY 2010	FY 2011
Hypersonics Flight Demonstration (HyFly)	1.500	1.200	1.000	

(U) The Hypersonics Flight Demonstration program (HyFly) 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 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 2008 Accomplishments:
- Conducted Flight 2 at Pacific Missile Test Range; launched from an F-15.
- Completed Flight 2 engine investigation.
- Initiated subsystem design changes.

FY 2009 Plans:
- Conduct testing of modified subsystems.
- Conduct fuel system and nose assembly shock and vibration testing.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Fabricate major engine components. *FY 2010 Plans:* - Assemble flight vehicle, perform ground testing and check-out. - Conduct third flight test.				
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, and 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 2008 Accomplishments:* - Conducted modeling, simulations, and experiments to develop an understanding of cavity and vehicle interactions and the effect of these interactions on vehicle design, control and stability. - Modeled, simulated, and experimentally measured vehicle maneuvering and body forces in a controlled facility. - Developed vehicle and cavity scaling relationships. *FY 2009 Plans:* - Conduct modeling, simulations, and experiments to refine understanding of cavity and vehicle control and stability.	11.707	11.758	11.554	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Continue development of vehicle design including propulsion system design and integration, and design, fabrication and testing of a scaled prototype vehicle. *FY 2010 Plans:* - Design, fabricate and commence testing of a scaled vehicle. - Analyze vehicle performance for speed, power and stability.				
Long Range Anti-Ship Missile Demonstration (U) In response to emerging threats, DARPA is building on the technology advances developed under the Hypersonics Flight (HyFly) demonstration program also funded in this project, 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 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 prototype demonstration weapon system. The program will result in high fidelity demonstration to support military utility assessment. Beginning in FY 2010, this program will be funded from PE 0603286E, Project AIR-01, Advanced Aerospace Systems. *FY 2009 Plans:* - Conduct threat modeling. - Complete system performance operations analysis. - Complete analytical trade studies to select seeker and datalink subsystems. - Complete subsystem preliminary designs. - Initiate integrated system preliminary designs. - Commence risk reduction testing of critical seeker, propulsion, and aerodynamic components.	.000	24.535	.000	
Extremely Long Endurance Unmanned Surface Vehicle (ELEUSV)	.000	1.400	3.500	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) The Extremely Long Endurance Unmanned Surface Vehicle (ELEUSV) program will evaluate radical large scale unmanned surface platforms with corresponding increases in capability to support high demand naval missions. Current unmanned surface platforms in development are adjuncts to be operated from and in support of conventional manned ships. The next step in full exploitation of this technology is larger scale unmanned vessels that can operate independently at the theater or global level, much like the Global Hawk unmanned air vehicle does today. By focusing on surface platforms that are never intended for a person to step aboard at any point in the operations cycle, an unexplored design space emerges without constraint on structure, stability, or crew support, in contrast to their significant impacts in conventional ship design. The ELEUSV program will explore how those overhead limitations can be converted into meaningful operational performance metrics such as speed, payload, survivability, or reduced construction cost. In order to make these radical ship designs operationally feasible, significant emphasis will be placed on automated maintenance and repair, system operational autonomy and command and control, and payload employment concepts. *FY 2009 Plans:* - Conduct analysis of unmanned naval vessel concepts and operational employment. - Identify core technologies required to enable unique large scale unmanned naval vessel capabilities. - Develop system concept designs and begin platform and payload preliminary design efforts. *FY 2010 Plans:* - Complete system preliminary design. - Demonstrate critical subsystem technologies. - Commence system final design.				
Broad Ocean Demining (U) The Broad Ocean Demining program will develop and demonstrate technologies that allow for the rapid detection and direct neutralization of mines and other asymmetric littoral threats over broad areas. Current mine clearance approaches rely on expendable neutralizers to be placed on each mine target. The operational cost of emplacing each neutralizer demands extensive prior activity to positively differentiate mines from other mine like objects in the operating area, and to precisely locate the mine	.000	.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
target so that the neutralizer can be placed within its effective range. By developing technologies that can positively defeat in place mines without reliance on expendable neutralizers, the Broad Ocean Demining program will reduce or eliminate these activities and demonstrate dramatic acceleration of area mine clearance timelines. By eliminating the need for explosive neutralizers, the program will also provide a credible mine clearance capability that can be readily dispersed and employed by military and non-military entities to improve rapid contingency response. Technologies and approaches will be explored for the range of littoral threats to enhance naval force operational freedom and effectiveness. *FY 2010 Plans:* - Identify core technologies to enable affordable and effective defeat of littoral threats. - Develop broad ocean demining architectural concepts and system plans. - Implement selected operational system design efforts. - Conduct risk reduction demonstrations of critical enabling technologies.				
Center of Excellence for Research in Ocean Sciences (CEROS) (U) The Center of Excellence for Research in Ocean Sciences (CEROS) encourages leading edge research and development in ocean sciences by involving highly specialized small businesses with recognized expertise in ocean related research and providing access to potential Department of Navy transition partners. Major research areas of interest have included shallow water surveillance technologies, sensor communications, ocean environmental preservation, new ocean platform and ship concepts, ocean measurement instrumentation, and unique properties of the deep ocean environment. *FY 2008 Accomplishments:* - Completed projects started in FY 2007. - Selected projects for FY 2008 funding. - Contracted for selected projects and monitored progress of ocean related technologies of high interest to the DoD. *FY 2009 Plans:* - Complete projects started in FY 2008.	10.000	10.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Select projects for FY 2009 funding.				
Submersible Aircraft (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 project will exploit lightweight materials, unique dynamic structures and advanced propulsion systems to overcome the technical barriers to achieving this capability. If successful, the project 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 designs 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.	.000	.000	3.000	
Non-traditional Littoral Active Sonar (U) The goal of the Non-traditional Littoral Active Sonar program is to develop solutions for active sonar that do not rely on the use of legacy high-power pulsed 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 acoustic energy spread over space or time as a means to counter the need for high peak power sonar. Once the challenges of low power, complex interference and propagation are overcome, complete new strategies and systems for active sonar will emerge. *FY 2010 Plans:* - Initial phenomenology testing and proof of principal detection demonstrations.	.000	.000	2.000	

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0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	PE 0602702E TACTICAL TECHNOLOGY	TT-03

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
SeaCatcher Unmanned Aircraft Launch and Recovery System *FY 2009 Plans:* - Explore launch and recovery system concepts.	.000	1.600	.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 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
TT-04: ADVANCED LAND SYSTEMS TECHNOLOGY	53.415	65.891	36.494						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 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Guided Projectiles	4.926	3.330	.000	
(U) The Guided Projectiles program is developing and demonstrating 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 will develop 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. Based upon this information, the accuracy and effectiveness of the weapons are increased and the potential for collateral damage is reduced. This program will adapt recent advances in communications, computers, sensing and propellants/explosives to demonstrate significant leaps in combat capability. The technologies developed will demonstrate the increased combat effectiveness and the reliability of distributed, collaborative processing and mission execution. (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				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
investigated for application to the 81mm and 120mm mortars to increase the accuracy and effectiveness of all fielded mortar rounds at a low cost. (U) This program will now leverage the innovative low-cost optical seeker technology to develop an affordable fuse-guidance package that converts a conventional 81mm or 120mm mortar round into a precision-guided munition. This program will further extend this development to the development of laser-guided munition systems wing-dropped from tactical UAVs and guidable from the on-board laser designator to any target within the field of view (FOV) of the designator. Critical developments supporting this program include component or packaging development technologies that enable the guidance sensors and actuators to sustain the 20-40,000g peak launch stresses, and the development of guidance systems that integrate low-cost GPS and terminal laser lock-on. *FY 2008 Accomplishments:* - Developed a low-cost optical seeker applicable to 81mm and 120mm mortar rounds and UAV-borne munitions. *FY 2009 Plans:* - Design integration plan for incorporating test seeker-guidance system on large caliber (81mm or 120mm) mortar rounds.				
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 standoff detection of various devices. *FY 2008 Accomplishments:* - Demonstrated laser filamentation at 100 meters using low power lasers. *FY 2009 Plans:* - Demonstrate operation of compact, tunable lasers from deep ultraviolet (UV) to near infrared (NIR).	3.103	6.704	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Develop integrated sub-system consisting of optical detector and compact laser for detection of explosives.				
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 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 timed 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 2008 Accomplishments:* - Refined existing modeling capability and augmented with new modeling tools to replicate performance of various experiments, allowing identification of issues computationally as well as allowing iteration on initial designs to improve performance. - Continued helical generator (HG) design and fabrication. - Completed component and full unit testing at the Air Force Research Laboratory Chestnut Explosive Test Site. - Designed and tested an end-initiated, shorter, ‘unified’ generator.	3.981	3.705	3.215	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Test a static prototype of a self-contained MAHEM munition to demonstrate the ability to package a MAHEM device into an AT4-CS form factor including setback and jet penetration tests. *FY 2010 Plans:* - Explore additional applications of MAHEM technology including use as a small sized penetrator warhead for both ground-to-ground and air-to-ground anti-armor, localized electronic attack modification, and finally potential as a long range air-to-air/air-to-surface weapon.				
Lightweight Ceramic Armor (LCA) (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 tradeoff 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 2008 Accomplishments:* - Developed lightweight ceramic armor with high dynamic tensile stress to effectively dissipate shock waves. - Investigated backing materials or materials systems for optimized energy dissipation characteristics when used in combination with this new class of ceramics. - Developed improved processing of initial ceramic powder materials for improved ceramic performance, part yield, and yielded cost.	6.114	5.426	2.000	

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Develop and model a scalable manufacturing process design for a pilot scale fabrication system capable of producing sufficient high performance ceramic material plates to support the end-manufacture of 1,000 systems per month. - Validate an initial fifteen percent reduction in weight for equal performance compared to currently fielded Enhanced Small Arms Protective Inserts (ESAPI) armor inserts. - Optimize integrated backing materials - ceramic armor materials systems for minimum weight at ESAPI ballistic performance. - Evaluate the characteristics of an optimized LCA system optimized for minimum weight at ESAPI ballistic performance. - Investigate the potential for significantly improved ballistic characteristics of meta-structured ceramic systems incorporating multiple materials layers in a monolithic plate. - Validate a thirty percent reduction in weight for equal performance compared to currently fielded ESAPI armor inserts. - Develop and evaluate initial concepts for ballistic headgear incorporating the LCA materials. *FY 2010 Plans:* - 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) have entered into an MOA for Phase	7.400	17.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
IIA. Phase IIA consists 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 goal of Phase IIB will be to integrate the final Crosshairs system with an appropriate active protection system (APS). (U) The Concept of Operations is to provide a military vehicle with a mounted detection and response system that operates both stationary and on the move. Bullets will be detected and localized using the acoustic DARPA-developed Boomerang v2.5 acoustic gunfire detection system. Radar detection of all other threats will be made using the Crosscue radar. The Crosscue radar is a dual mode, continuous wave, and pulsed Doppler radar, which will be used to determine range, velocity, and azimuth of the incoming threat. It is envisioned that the system will provide a significantly improved capability to detect and respond to incoming threats during hostile and peacekeeping operations in both urban and non-urban environments. Technology challenges include: low false alarm rate, algorithm development, high speed sensor and data processing for 360 degree azimuth and sixty degree elevation detection zone; robust data collection to locate firing source; and fast response time. The program will culminate with a demonstration of two prototype systems in a typical combat environment. Additionally, the program is investigating the feasibility of a variety of technologies to detect enemy shooters before the firing of a weapon. *FY 2008 Accomplishments:* - Analyzed data and integrated sensors and response system for initial on the move capabilities. - Performed on the move tests with the Vanguard vehicle. - Enhanced on the move sensor system capabilities to include decreasing false alarm and false tracks. - Developed and hardened sensor system. - Identified second overhead weapons station for integration on the Crosshairs vehicle. - Performed on the move testing of the integrated Crosshairs system against a variety of threats. - Integrated overhead weapons station with the Crosshairs vehicle. *FY 2009 Plans:* - Demonstrate the final system capability in live fire tests. - Demonstrate networking capability between two Crosshairs sensor systems.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Begin integration of the APS with the Crosshairs vehicle. - Perform stationary live fire tests of the Crosshairs system integrated with APS. - Demonstrate on the move capability of the integrated system in live fire tests. *FY 2010 Plans:* - Demonstrate the final integrated system capability in live fire tests. - Transition Crosshairs technology to the military.				
Rocket Propelled Grenade (RPG) Nets	4.722	6.079	3.494	
(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 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. *FY 2008 Accomplishments:* - Developed near-term net concepts and performed live fire evaluation. - Began concept development for active net system. *FY 2009 Plans:* - Install near-term net systems on military vehicles and perform initial user evaluation. - Complete user evaluation of near-term net system and transition system. - Complete active net concepts and perform live fire testing. *FY 2010 Plans:* - Begin user evaluation of active net system.				
Small Combat Vehicle with Robotic Automation	.000	3.000	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Small Combat Vehicle with Robotic Automation program will evaluate and design small, survivable, highly mobile ground combat vehicles that have combat firepower equivalent to today's larger ground vehicles (e.g. M2/M3 Bradley) but in a highly deployable package of five to ten tons with a single crew person/operator on board (with the option for operation with no crew person in an unmanned configuration). Smaller vehicle weights enable effective deployability in helicopters or C-130 aircraft for vertical envelopment. This program seeks to achieve an optimal mix of manned and unmanned technologies in a small, well protected, highly deployable combat vehicle. By utilizing automation technologies in vehicle driving and vehicle payload systems (reconnaissance sensors and weapons), a single crew person in the combat vehicle can effectively drive and operate payloads concurrently at appropriate times while still providing high-level supervisory control over all systems. At mission critical times, the crew person can be removed and supervisory control can be given off-board from a separate controlling vehicle. The key technologies that enable a Small Combat Vehicle with Robotic Operation include sensor-based autonomous and semi-autonomous navigation, robust indirect driving (via combinations of cameras, perception-generated views of the terrain, or teleoperation), robust supervisory semi-autonomous control and teleoperation to allow vehicle operation from another vehicle, high density low-weight armor, aided target acquisition and targeting-based remote weapons stations, effective but minimalist warfighter-machine interfaces for crew person interaction with semi-automated driving and payload systems, and high performance vehicle mobility systems (suspensions and drivetrains). *FY 2009 Plans:* - Conduct initial studies and develop vehicle automation concepts. - Conduct experiments and evaluations of candidate technologies. *FY 2010 Plans:* - Initiate preliminary designs.				
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 Rocket Propelled Grenade (RPG) attacks, improve their ability to respond, and provide affordable defeat of RPGs or other rockets. System effectiveness with	4.050	5.949	6.200	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 and RPGs, shooter localization, and threat mitigation/defeat. *FY 2008 Accomplishments:* - Conducted component testing of the acoustic system during flight testing. - Completed prototype system level integration with existing aircraft survivability equipment. - Examined rocket threat detection and termination. - Conducted final acoustic component testing and demonstrated the prototype system. *FY 2009 Plans:* - Integrate acoustic prototype system with existing aircraft survivability equipment such as the Common Missile Warning System. - Install prototype HALTT-A(coustic) systems on platforms for training and CONOPS evaluations. - Deploy the HALTT-A prototype system in operational evaluation scenarios. - Develop HALTT system preliminary design and system integration plan. - Begin analysis of defeat mechanisms against RPGs. - Perform live fire testing of individual subsystems. *FY 2010 Plans:* - Provide HALTT-A kits for user evaluation. - Initiate and demonstrate HALTT-R(ocket) detection system. - Demonstrate HALTT-R counter measure.				
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	7.945	9.898	6.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
cluttered urban environments. The C-Sniper system will operate day and night from a moving military vehicle and 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 2008 Accomplishments:* - Conducted feasibility studies of promising technologies to detect enemy shooters before the firing of a weapon. *FY 2009 Plans:* - Develop the key technologies (laser system, sensor head, and system processing designs). - Develop the interfaces of the sensor system to integrate with Crosshairs. - Conduct systems integration and test on stationary vehicle. - Develop and incorporate 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. - Conduct maritime application feasibility studies to investigate technologies that would enable enemy periscope detection at significant tactical ranges.				
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, and 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	.000	3.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
false alarms and false positives will be key, as will be true day/night operation and the simultaneous identification of up to five threats. *FY 2009 Plans:* - Develop and mature detection and classification algorithms. - Breadboard test of detection and classification algorithms. - Perform a system demonstration of pre-launch threat detection with stationary cameras. *FY 2010 Plans:* - Perform on-the-move sensor demonstrations of pre-launch threat detection. - Continue to mature detection and classification algorithms. - Integrate technologies for systems application for vehicle mounting and integration. - Interface with existing vehicle sensors to develop a full pre-launch threat detection and cueing capability.				
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 methods for detecting sensitive explosives in an urban environment that will minimize interference with troop operations and collateral damages. The goal is to develop efficient techniques for collection of trace explosives that are sufficiently selective and sensitive to be deployed in the field and provide a clear and fast identification of the target explosive.	1.505	1.000	.585	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Identified a physical method to neutralize/desensitize bulk explosive materials. - Conducted feasibility demonstrations to neutralize/desensitize up to 1 Kg of the pure target explosive and mixtures. - Optimized and demonstrated the sensor on pure target explosives and mixtures. *FY 2009 Plans:* - Develop prototype sensor kit. - Test neutralization/desensitization methods on “field-form” mixtures of explosives. - Design concept of multi-structures “smart” wipe. - Develop methodology of direct spectroscopic analysis of wipe. - Develop prototype of nano-fiber based “smart” wipe. *FY 2010 Plans:* - Demonstration of nanostructure based “smart” wipe. - Develop and field test prototype “smart” wipe.				
Maneuver and Control on the Urban Battlefield (U) This program developed new, high-speed, lightweight, and portable tools including bar cutters, rotary cutters, 5-25 ton spreaders, jamb breakers, deployable personnel barriers, and rooftop access devices. The ultimate program goal was to reduce the weight of existing access tools by eighty percent as well as deliver new and unique capabilities such as direct and rapid rooftop access and rapidly deployed personnel barriers. *FY 2008 Accomplishments:* - Initiated integration of energy storage, power delivery, and end effector components into a single portable lightweight rescue spreader.	2.998	.000	.000	
Optical Sensor System	.800	.800	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Researched optical sensors. *FY 2009 Plans:* - Select sensor and develop processing for defeat of explosively formed projectiles.				
Novel Sensors for Force Protection (U) The Novel Sensors for Force Protection program explored novel methods that addressed hostile situations to enhance U.S. warfighter protection in the Global War on Terrorism, Operation Enduring Freedom and Operation Iraqi Freedom. *FY 2008 Accomplishments:* - Completed studies to identify the specific regions of the mouse and human genome associated with odorant production in mice and humans.	5.871	.000	.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 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
TT-06: ADVANCED TACTICAL TECHNOLOGY	90.867	118.751	88.129						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 2008**	**FY 2009**	**FY 2010**	**FY 2011**
High Power Efficient and Reliable Laser Bars (HiPER)*	4.000	4.000	.000	

*Formerly Super High Efficiency Diode Sources (SHEDS).

(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.

FY 2008 Accomplishments:
- Demonstrated laser diode bars operating at seventy-two percent efficiency and at 80 watts per bar.
- Demonstrated an array of vertical-external-cavity surface-emitting laser (VCSEL) laser diodes operating at high-power density and high efficiency.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Established methods to increase diode power output by increasing laser cavity length without sacrificing efficiency. - Demonstrated improvements in diode lifetime through suppression of filamentation and other laser diode instabilities. - Enabled diode operation at increased inlet water cooling temperatures. - Acquired lasers and established test bed. - Performed laser testing under fault protection to extend diode lifetime. - Performed data reduction and failure mode analysis. *FY 2009 Plans:* - Demonstrate 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. - Demonstrate novel, compact impingement cooling technology to increase laser diode bar cooling technology and enable 1000 W laser diode bars operating with 1.8mm pitch.				
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. The HELLADS program has completed the design and demonstration of a revolutionary prototype unit cell laser module that has 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 competing 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, power, heat exchange, safety, and command and control subsystems that are based upon existing technologies to produce a laser	32.665	40.608	35.388	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. The HELLADS laser will then be transitioned to the Air Force for aircraft integration and flight testing. *FY 2008 Accomplishments:* - Fabricated a test head and characterized the optical performance of the test head. - Initiated development of a second approach for a HELLADS unit cell laser module that meets all performance requirements. - Completed preliminary design of a 150 kW laser weapon system demonstrator. *FY 2009 Plans:* - Fabricated a prototype unit cell and characterized power output and optical wavefront of the prototype unit cell. - Complete a unit cell laser module with integrated power and thermal management subsystems and demonstrate power, beam quality, run-time, weight, and volume. - Complete detailed design of a 150 kW laser weapon system demonstrator. - Initiate field testing of individual laser weapon system components. - Perform static lethality testing against targets to be utilized in the field demonstration of the 150 kW laser weapon system. *FY 2010 Plans:* - Initiate fabrication of additional unit cell laser modules to complete the 150 kW laser. - Complete the fabrication and laboratory testing of the 150 kW laser. - Complete fabrication of the demonstrator laser weapon system. - Complete demonstrator laser weapon system component and subsystem testing. - Initiate integration of the 150 kW laser with the laser weapon system.				
Aero-Adaptive/Aero-Optic Beam Control (ABC)	4.000	5.000	4.890	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

(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 now 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 2008 Accomplishments:
- Initiated trade studies and computational fluid dynamics (CFD) analyses.
- Characterized turret aero-optical performance with CFD analysis and small-scale wind tunnel testing.
- Downselected to preferred turret configuration.

FY 2009 Plans:
- Use CFD analyses to optimize blowing slot configuration.
- Assess wavefront measurements for a range of pointing angles.
- Downselect flow control actuation technique.
- Model effects of adaptive optics on system performance.
- Assess 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.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Perform bench-level evaluation of system functionality using phase screens.				
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 sections, and efficient automatic mapping and optimization of signal processing kernels onto advanced departmental computational hardware architectures. After a review of program goals and content, two efforts funded under this program, 23 Mathematical Challenges and Focus Areas in Theoretical Mathematics, were reclassified as basic research and moved to PE 0601101E, Project CCS-02 beginning in FY 2009. *FY 2008 Accomplishments:* - Extended methods from kernels to end-to-end applications including JPEG2000, Viterbi coding, and Synthetic Aperture Radar (SAR) processing. - Extended time reversal theory to form complete images of targets in multipath environments. - Tested hypothesis that multipath scattering will enable portions of the target that are not illuminated to be imaged. - Developed test range facility and clutter environment to support experimentation at Ka band. - Extended methods to cope with nonlinear systems with dimensionality greater than 10,000 degrees of freedom. - Accelerated the methods to achieve 100 times performance over particle filtering and Monte Carlo sampling.	12.931	5.200	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Demonstrated the method in 2.5 dimensions with over 10,000 degrees of freedom. - Developed novel clustering algorithms that address stochasticity and uncertainty. - Expanded software tool capability and functionality to address complex datasets of military importance. - Injected novel mathematical tools into quantum physics calculations. - Developed new mathematical approaches to approximate infinite calculations by polynomial ones. - Demonstrated new mathematical results in large scale computation based on novel multi-parameter filtering methods. - Developed new mathematical results in rigid geometry based on novel algorithms. - Demonstrated new mathematical results in expander graph technology for potential applications to materials science. *FY 2009 Plans:* - Develop 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. - Identify the signatures of information/target message endurance among disparate groups and cultures through measures of neuroscience and behavior. - Demonstrate 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. - Extend DESA tool suite to other common signal processing and image formation algorithms. - Extend time reversal methods to acoustic channels and increase the computational speed of the Green's function by 100. - Use topological tools to analyze higher-order datasets in biology, sensing, and neuroscience. - Develop 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 altruism, persuasion, and trust in individuals, dyads and groups.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- 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. - Develop and use novel topological tools to analyze non-linear dynamical systems. - 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 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.				
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. *FY 2008 Accomplishments:* - Established topological methods for deterministic target enumeration. - Established novel algorithms to guarantee capture in pursuit and evasion scenarios in non-convex domains.	4.373	7.500	6.400	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Developed new algorithms for reaching consensus among independent agents in motion planning and resource allocation. - Extended the registration methods for two-dimensional (2-D) (electro-optical and video) data and three-dimensional (3-D) laser imaging detection and ranging (LIDAR) data from complex urban environments. - Extended the elevation data compression methods for three-dimensional LIDAR point clouds for evaluation in path planning applications. *FY 2009 Plans:* - Transition compression technology to National Geospatial Agency commercial geospatial products. - Extend 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.				
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 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.	8.791	13.071	8.900	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Created compelling, digital tutor training for Navy information technicians that trains as well as the best human tutors. - Designed experiment and developed metrics to demonstrate and validate the effectiveness of Digital Tutor training in schoolhouse setting. - Began knowledge elicitation efforts for building full scale Digital Tutor. *FY 2009 Plans:* - Demonstrate forty hour Digital Tutor, teaching one week of content, in a production software configuration. - Port three weeks of content from a human-tutored course to the Digital Tutor and test in a laboratory setting. - Validate knowledge elicitation data for full scale Digital Tutor in a leading Information Technology (IT) school setting. - Conduct and evaluate the first Information Warfare Cup (IWARS Cup) using the human-tutored team to provide real-world validation of Digital Tutor training methodology. *FY 2010 Plans:* - Port two months of Navy IT-School content from a human-tutored course to the Digital Tutor. - Elaborate intrinsic, instrumental and extrinsic motivation models in order to maintain student motivation over two months of instruction demonstrated over one week. - Create an automatic capability to identify students requiring remediation.				
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	7.200	12.125	7.494	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated automated geo-specific terrain from digital terrain elevation data. - Demonstrated scalability to 250 live network participants running on a single server, thus surpassing current DoD multi-player capacity. - Demonstrated integration of Newtonian physics. - Applied RealWorld simulation builder to digital cockpit training. - Transitioned RealWorld Air component to Air Force as the universal trainer for A-10C. - Applied RealWorld simulation builder to electronic warfare applications. - Transitioned RealWorld Electronic Weapons Officer component to Air Force. - Scaled to 500 entities. - Demonstrated three-dimensional (3-D) positional audio, multi-channel audio and physical modeling of communications jamming effects including multi-spectrum and frequency jamming. - Implemented an artificial intelligence (AI) Abstraction layer allowing the future integration of disparate AI systems. - Ingested 1 sq. km. of government terrain data into a physics based 3-D real-time software environment in thirty minutes. - Ingested 360 sq. km. of government terrain data into a physics based 3-D real-time software environment in four hours. - Created up to 38,000 sq. km of terrain data for air specific missions, anywhere in the world, in one hour. - Automatically generated the interior (including furniture and stairways) and exterior of a geo-typical building of any size or footprint in under five minutes that includes building material types by zip code. - Initiated development of a universal medic simulation builder. - Demonstrated utility as a trainer for at least one Special Operations Command (SOCOM) application.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Demonstrate dynamic path finding such that entities will be able to maneuver in a terrain deformed geo-specific area. - Integrate a full Newtonian physics modeling engine in a real-time 3-D engine in both a hardware enhanced and software only modality. - Transform 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. - Ingest up to one square mile of LIDAR terrain data and render 3-D models in less than one hour. *FY 2010 Plans:* - Scale to 1000 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.				
Discharge Excited Catalytic Oxygen Iodine Laser (DECOIL)* *Formerly Air Laser. (U) The objective of the Discharge Excited Catalytic Oxygen Iodine Laser (DECOIL) program is to investigate 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. DECOIL offers the potential of an open or closed cycle, electrically powered system with minimal stored consumables, no toxic, complex, and massive chemical storage and handling, and all the advantages of COIL such as excellent beam quality, operation in an atmospheric window, and high power operation. The goals of the DECOIL program are to demonstrate 1 kilowatt laser output, and develop a preliminary design for a 150 kilowatt laser system.	1.000	2.000	.000	

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0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	PE 0602702E TACTICAL TECHNOLOGY	TT-06

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Developed and demonstrated a 1 kW output power laser design. *FY 2009 Plans:* - Demonstrate laser outcoupled power of = 100 Watts. - Demonstrate beam quality (M2) of = 1.2. - Demonstrate wallplug electrical efficiency of = 10 percent.				
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 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 2008 Accomplishments:* - Demonstrated the projected efficiency, power and beam quality levels from single-mode Indium Phosphide (InP)-based QCL emitters. - Demonstrated device mounting modeling and fabrication for reduced electrical and thermal resistance.	5.700	7.900	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Tested final device integration. *FY 2009 Plans:* - Scale 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.				
Sonic Projector (U) The goal of the Sonic Projector program is to provide the services with a method of surreptitious audio communication at distances over 1 km. Sonic Projector technology is based on the non-linear interaction of sound in air translating an ultrasonic signal into audible sound. The Sonic Projector will be designed to be a man-deployable system, using hardware and signal processing algorithms which result in clear audible signals at the desired location and unintelligible sound at locations away from the desired location. The Sonic Projector system could be used to conceal communications for special operations forces and hostage rescue missions, and to disrupt enemy activities. *FY 2008 Accomplishments:* - Conducted analysis for high-power ultrasonic transducers, and precision beam control and focus for location tracking. *FY 2009 Plans:* - Develop transducer array design for far-field propagation. - Evaluate concept of operations.	2.437	1.000	.000	
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	3.552	11.330	10.551	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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 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 2008 Accomplishments:* - Performed final engineering designs of a 1 kW coherently combinable fiber amplifier (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). *FY 2009 Plans:* - Initiate 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). - Complete 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.				
Coherently Combined High-Power Single-Mode Emitters (COCHISE) (U) The Coherently Combined High-Power Single-Mode Emitters (COCHISE) program will develop four new, breakthrough technologies that will result in improved diode bar lifetime and beam quality. Ultimately, these technologies will also lead to coherent combination of individual emitters in laser diode bars and	2.300	5.017	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
arrays. Coherent combination of laser diode arrays would provide high power laser architectures that are up to three times more efficient than existing diode-pumped solid-state laser technology, while improving beam quality and increasing far-field, on-axis intensity. *FY 2008 Accomplishments:* - Demonstrated a diode bar pre-screening technology based on spectral measurements made on each emitter that can detect <1 degree Celsius temperature changes among these emitters simultaneously and that can detect packaging defects and other manufacturing defects (High Energy Liquid Laser Area Defense System (HELLADS) diode bars). - Correlated electrical fault mode detection based on voltage drops at the diode terminals with optical fault mode detection based on spectral splitting in diode or bar emission (>seventy percent correlation). - Demonstrated that fault mode frequency as detected electrically at the diode bar terminals correlates with diode bar lifetime – use as an additional diode bar pre-screening technology. - Demonstrated that SHEDS/HiPER laser diode bar lifetimes can be extended beyond 500 hrs at full efficiency and power with fault mode protection. - Demonstrated phase control of individual slab-coupled optical waveguide lasers (SCOWL) emitters to >0.1 waves with a compact diode driver containing integrated fault-mode, protection and the ability to cut current to the SCOWL diode in <2 microseconds. *FY 2009 Plans:* - Demonstrate coherent combination of a bar of single mode SCOWL diodes at 10 W with 1.4x diffraction limited beam quality. - Develop electrical power supply, microscale power distribution, and holographic optical elements to support coherent combination of 10 bars of SCOWL laser 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 laser diodes at a total power of 100 W with better than 1.4x diffraction limited beam quality and at better than 30% electrical efficiency.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Demonstrate coherent combination of 30 bars of single mode SCOWL laser diodes at a total power of 1000 W with better than 1.4x diffraction limited beam quality at better than 40% efficiency.				
Architecture for Diode High Energy Laser Systems (ADHELS) (U) The Architecture for Diode High Energy Laser Systems (ADHELS) program is developing technology to allow scaling of spectral beam combining of high power fiber laser amplifiers to power levels greater than 100 kW. Such high power laser systems would result in overall electrical efficiencies exceeding 30% with near-diffraction-limited beam quality and electric laser systems that are more than ten times lighter weight and more compact than existing chemical laser systems. *FY 2008 Accomplishments:* - Demonstrated a moderate-power spectrally combined fiber laser with high-efficiency and good beam quality. - Demonstrated a surface-emitting distributed feedback (SE-DFB) laser diode operating at high-power, high-efficiency and good beam quality. - Demonstrated volume Bragg gratings suitable for high-power beam combining and good spectral efficiency. - Demonstrated a moderate-power laser with record-high efficiency and excellent beam quality. - Demonstrated a SE-DFB laser diode operating at high-power, record-high efficiency and excellent beam quality. - Demonstrated volume Bragg gratings suitable for high-power beam combining and high-spectral efficiency. *FY 2009 Plans:* - Design a 700 W, ultra-high spectral density, spectrally combined fiber laser amplifier system using efficient, diffraction-limited, volume Bragg gratings. *FY 2010 Plans:* - Construct and test a 700 W, ultra-high spectral density, spectrally combined fiber laser amplifier system using efficient, diffraction-limited volume Bragg gratings.	1.918	1.000	.506	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
GORGON - High Power Mid-IR Laser	.000	3.000	4.000	

(U) GORGON, a High Power Mid-IR laser program, will develop advanced laser technologies to provide infrared counter measures (IRCM) capabilities for a variety of airborne platforms in conjunction with the Multi-function Electro-optical Defense of U.S. Aircraft (MEDUSA) program. Defense of aircraft against incoming IR guided missiles, especially man-portable air-defense systems, represents a crucial capability with vital applications in both the military and commercial sectors.

(U) Two technologies will be developed in this program. The first technology is based on a Thulium: yttrium lithium fluoride (YLF) thin slab lasers operated in a zigzag configuration to preserve beam quality at high average power. This laser offers the ability to store the energy invested in population inversion for up to 500 microseconds so that efficient, Q-switched formation of short pulses is possible. In addition, this laser system can provide the required 100 nanometer tunability as well as efficient operation with available ultra-high efficiency pump diodes. This concept offers near-diffraction limited beam quality and output power scalable to levels ultimately required for negation of IR detectors at long range.

(U) The second technology is a laser based on double-clad erbium (Er)-doped zirconium barium lanthanide sodium fluoride (ZBLAN) fiber pumped with 975 nanometer wavelength laser diode bars. Using 4 meter long fiber, researchers have demonstrated 9 Watts of continuous-wave output at 3 micrometers. To achieve this power increase, the natural population-inversion bottleneck caused by the longer lifetime of the lower laser level relative to the upper laser level for the Er atoms was overcome by using a heavily Er-doped ZBLAN double-clad fiber. A technique called energy-transfer upconversion was used, in which an energy-transfer process between Er ions solves the population bottleneck and increases the output power. The laser was pumped with 43 Watts of optical power and its slope efficiency was over twenty-one percent. The infrared output was limited by optical damage of the pumping end facet. The challenge is to produce ZBLAN fibers capable of withstanding higher optical fluxes and longer wavelength emission.

FY 2009 Plans:
- Demonstrate 10 Watts average power.
- Demonstrate 30 nanometer tunability.
- Demonstrate beam quality better than 5x diffraction limited.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Demonstrate 25 Watts average power. - Demonstrate 75 nanometer tunability. - Demonstrate beam quality better than 3x diffraction limited.				

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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TT-07: AERONAUTICS TECHNOLOGY	37.067	48.201	50.066						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 2008	FY 2009	FY 2010	FY 2011
Helicopter Quieting	9.900	6.000	3.800	
(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 to analytically develop advanced rotor technologies that can dramatically improve 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 design 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 fluid dynamics techniques. The program will develop tools capable of accurate prediction of the noise signature of advanced, rotor concepts that exhibit a significant reduction in low-frequency in-plane signatures.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) This program will also undertake the development of 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 2008 Accomplishments:* - Validated and applied high-fidelity, physics-based rotor acoustic predictive tools for rotors that exhibit complex aerodynamic phenomena atypical of conventional, fielded rotorcraft. *FY 2009 Plans:* - Deploy near real-time mission planning and visualization tool set capturing and displaying the rotorcraft's acoustic probability of detection. - Complete and deliver Beta test software for supersonic show-of-force missions. *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. - Develop capability to dramatically enhance reduced perception and supersonic show-of-force missions. - Analytically demonstrate dramatic survivability improvement through reduced acoustic signature (Sonic Evasion). - Demonstrate dramatic improvement to supersonic show-of-force missions.				
Nano-Flapping Air Vehicles (U) The goal of this program is to develop a flapping and rotary air vehicle technology that results in a bio-inspired flapping and rotary air vehicle with less than a two inch wingspan and gross take-off weight of approximately ten grams or less. Operations in the urban terrain require sensors that can navigate	9.726	5.000	2.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. Key enabling technologies include: flapping and rotary wing aerodynamics, kinematics and flight dynamics, lightweight aeroelastically tailored wing structures, miniature navigation systems, micro-propulsion systems, small payloads, and the ability to perch like a bird. This effort will also examine novel materials that can be used to develop integrated wing structures, which change composition to achieve multiple expressions. The program would result in the use of vehicles, which could be camouflaged, or blend into the surrounding landscape, enabling in-theater disposal and prevention of mission detection/compromise. *FY 2008 Accomplishments:* - Demonstrated robust flapping and rotary mechanisms that produce 10 grams of lift, integrated wing design with air vehicle, and demonstrated reliable flapping/rotary wing manufacturing principles. - Demonstrated image-aided navigation allowing the nano air vehicle to maintain station in an indoor environment by automatically tracking the position of features within video. - Demonstrated low-power, low-mass, high-deflection piezoelectric tilt-actuation of 7.5 cm rotating wing. *FY 2009 Plans:* - Demonstrate roll-pitch-yaw control of a flapping air vehicle using only wind-stroke modulation, modeled after birds and insects. - Demonstrate sustained hover of a flapping air vehicle. - Develop preliminary design of a flapping or rotary wing nano air vehicle and control system to assist platoon/squad level operation in urban and indoor environments. - Demonstrate on-board, autonomous image-aided navigation and collision avoidance. *FY 2010 Plans:* - Integrate light weight, low-power, low-light cameras to support nighttime urban operations. - Demonstrate prototype vehicle in urban combat missions.				
Battlefield Helicopter Emulator (BHE)	8.750	8.321	7.766	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(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 UAV. 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 ground fire, small arms, rocket-propelled grenades (RPGs), man-portable air defense systems (MANPADS), and anti-helicopter mines (AHMs). *FY 2008 Accomplishments:* - Identified technical approaches for adequately emulating critical signatures. - Characterized signatures of battlefield helicopters. - Developed concepts to emulate battlefield helicopter signatures. - Developed and tested emulator system to demonstrate technological feasibility in a laboratory environment. - Developed an analytical constructive simulation capability to assess performance of proposed technologies and mature key system performance criteria. *FY 2009 Plans:* - Demonstrate numerous emulator systems in multiple signature bands in a field test. - Select emulator systems for integration with UAV platform. *FY 2010 Plans:* - Integrate emulator systems onto tactical unmanned aircraft systems. - Conduct first flight, envelope expansion and performance characterization.				
Distributed Embedded Propulsion	.000	1.743	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Distributed Embedded Propulsion program explored using fully integrated engine/wing designs to take maximum advantage of a fully coupled engine/wing system. The concept involved utilizing multiple small engines to provide the thrust for the aircraft, and to allow the engines to be more readily integrated with the aircraft structure and the aerodynamics of the wing. *FY 2009 Plans:* - Conducted trade studies on aircraft sizing for short field take-off and landing and to determine the benefits of alternative propulsion systems in a distributed propulsion system. - Evaluated conceptual designs of distributed embedded propulsion concepts and assess aerodynamic performance.				
Drag Reduction Flight Demonstration* *Formerly Laminar Flow Flight Demonstration. (U) The Drag Reduction Flight Demonstration effort will explore the development of an extended laminar flow wing, with the potential for a drag reduction of up to twenty-five percent compared to a typical fully turbulent wing, and the development of a formation flight capability, with drag reduction up to seventeen percent compared to solo flight aircraft. In addition, this program will evaluate and demonstrate the ability for autonomous aircraft to compensate for arbitrary loss of flight control, e.g. due to battle damage. Crossflow instabilities dominate the transition process for swept wings. Recent advances in theoretical understanding of the crossflow receptivity and transition process have led to innovative, passive control concepts for the crossflow transition process. Test facilities are not available to demonstrate this flight concept in a quiet flow environment at flight-representative Reynolds numbers and Mach numbers. Flight testing a swept wing laminar flow control concept appears to be the most direct route to validation of this technology, enabling future aircraft designs to adopt passive crossflow control devices as a proven technology. 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. Flight testing a formation flight configuration will allow structural excitation, and vehicle dynamic response to be addressed in proximity to the lead aircraft wake.	2.000	4.300	7.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Evaluated design constraints for laminar flow wings. - Tested limits of damage tolerant control approach, including an initial implementation of automatic supervisory adaptive control. - Assessed potential aerodynamic benefit of 2 and 3 aircraft formations. *FY 2009 Plans:* - Conduct feasibility study of high Reynolds number flight test. - Conduct integration of damage tolerant controls across a range of flight conditions, including attitude control, upset recovery, redundancy management, and dynamic flight envelope restriction. - Assess legacy data from wake crossing studies to determine impacts on flight control systems. *FY 2010 Plans:* - Initiate design of flight test experiment. - Initiate design of laminar flow wing for demonstration. - Collect flight test data to assess autopilot faults, alarms, and structural response of the aircraft wing in proximity to the aircraft wake.				
Disc-Rotor Compound Helicopter (U) The goal of the Disc-Rotor 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 airplane flight would be 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 provide mobility and responsiveness for troop and cargo insertion, satisfy an ongoing military interest for higher speed VTOL and hover capable vehicles, be survivable and bridge the gap in helicopter escort and insertion missions. The enabling technologies are disc-rotor configuration, variable thrust ducted prop-fans, the extension of the telescoping blades and seamless reversible transition between hover and wing borne flight. Specific objectives of the Disc-Rotor	3.000	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 design and flight testing a demonstrator. Beginning in FY 2009, this program will budgeted in PE 0603286E, Project AIR-01. *FY 2008 Accomplishments:* - Developed a conceptual design and established performance metrics. - Identified the critical enabling technologies required to meet the performance goals.				
Integrated Compact Engine Flow Path (U) The goal of the Integrated Compact Engine Flow Path program is to fully integrate the aircraft structure and propulsion flowpath. This will include development of a structurally integrated, load bearing, composite, thrust vectoring nozzle. Integration of compact inlets and nozzles that are lightweight and survivable continue to be a challenge in military aircraft design. Multiple distributed inlets and nozzles may allow a better integrated wing and propulsion system, exploiting aerodynamic control possible with engine blowing and suction. Existing metal nozzles are cantilevered off the engine face and the airframe, with an overlap region to allow for thermal growth. This approach to nozzle integration results in heavy, high maintenance nozzles and is structurally inefficient. It also poses a significant engine integration challenge and can drive vehicle sizing. A fully integrated nozzle, designed to take airframe loads through the nozzle, and built of a high temperature ceramic, would address the weight and structural integration problems directly. This approach would also be compatible with fluidic thrust vectoring and would result in a more compact, lighter, and more durable nozzle. This program will design, develop, and demonstrate a full scale, integrated engine flowpath in a direct-connect engine test. *FY 2009 Plans:* - Perform combined temperature and pressure testing of a representative full-scale nozzle throat section. - Confirm predictive capability of combined thermal and pressure loading structural strains. - Initiate design trade studies to develop a preferred nozzle design as well as a development and demonstration plan.	.000	4.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Perform design studies for a dynamic loads test nozzle. - Perform detailed design of a ceramic matrix composite nozzle to be built of high temperature ceramics. - Assess benefits of an integrated engine flowpath on the aircraft performance.				
Active Rotor (U) The goal of the Active Rotor program is to develop and demonstrate enabling technologies that greatly enhance rotor control and performance, availability, sustainability, survivability, and affordability. Performance enhancement objectives are twenty-five percent improvement in endurance, range, and payload of existing helicopters. Sustainability includes increases in operational availability and readiness, and reductions in acoustic susceptibility. Enabling technologies include a dynamically controlled rotor, light-weight high-bandwidth on-blade actuators, and integrated vehicle flight control technologies. Over the past several decades, improvements in helicopter rotor performance have not kept pace with the increasing demands of the warfighter. This is apparent today in the high altitude environment of Afghanistan, where troop and materiel transport missions that are normally performed by the UH-60 Black Hawk are being performed by the much larger CH-47 Chinook due to the loss of performance in high/hot conditions. The Active Rotor program will mature the technologies to enable military aircraft such as the Black Hawk to operate effectively in this environment. The Active Rotor program will focus on development and demonstration of advanced technologies for application to future helicopter and tiltrotor and other rotorcraft platforms, with demonstration on a fielded system to enable application to new systems, and facilitate upgrade of current multi-service rotorcraft rotor systems. The effort will demonstrate technologies with broad applicability to military and commercial helicopters. *FY 2008 Accomplishments:* - Identified promising technologies for advanced lightweight high-bandwidth on-blade actuators, and studied dynamically controlled rotor performance. *FY 2009 Plans:* - Evaluate concepts for novel adaptive rotor systems.	1.591	4.837	7.800	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Characterize performance, survivability and support opportunities and benefits of adaptive rotor technology. - Develop designs for advanced actuators and model performance. *FY 2010 Plans:* - Conduct component technology demonstrations and initiate preliminary design of the Active Rotor System. - Perform sub-scale wind tunnel test of the Active Rotor System.				
Adaptive Morphing Super-Maneuver Aircraft (AMSMA) (U) The goal of the Adaptive Morphing Super-Maneuver Aircraft (AMSMA) program, a follow-on to the Morphing Aircraft Structure (MAS) program previously funded in PE 0602715E, Project MBT-01, is to demonstrate the practicality and the operational value of morphing aircraft technology in a full scale flight demonstration. This effort will lay the foundation for multi-mission aircraft such as a Hunter-Killer UAV platform with revolutionary capability and more broadly, for a new approach to overall aircraft design. AMSMA will build on the small scale demonstrations of the MAS program which established that air vehicles able to seamlessly change configuration in flight are capable of achieving near optimum performance across a range of contradictory missions that would not otherwise be possible with conventional designs. Real-time in flight configuration changing will enable AMSMA to fly efficiently at high or low speeds, to maneuver akin to birds, and to be adaptively survivable. This program will demonstrate an advanced morphing, highly maneuverable air vehicle that achieves high fuel efficiencies, translating to very long endurance times, as much as ten times better than comparative aircraft. It will incorporate a combination of enabling technologies, including asymmetric wing sweep, fore and aft wing translation, and aero-elastic wings with adaptive hinge-less control actuation. If successful, AMSMA could eliminate traditional flying controls while achieving efficient aerodynamic and maneuver performance over a wide range of speeds and altitudes. Shape changing will also be used to establish a new approach to tailored survivability. The AMSMA vehicle has the potential to have a revolutionary impact on prosecution of time sensitive targets. The concept will introduce a capability whereby one aircraft with the ability to effect multiple radical configuration changes is enabled to conduct a range of missions optimally; this provides the prospect of significant affordability gains through reducing the number of different aircraft types in	.000	4.000	6.200	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
existing military fleets. The AMSMA program will develop a morphing demonstrator vehicle to expand the flight envelope and to demonstrate revolutionary control and a super-maneuver capability through a series of measurable flight experiments. *FY 2009 Plans:* - Identify the capabilities, critical technologies, survivability approaches and performance goals to validate the morphing aircraft concept. - Establish vehicle performance and operating goals. *FY 2010 Plans:* - Develop a morphing concept demonstrator vehicle configuration that will affordably demonstrate optimized mission segment performance (e.g. high-speed dash), will achieve full maneuver capability including extreme new maneuvers, and will optimize tailored survivability.				
Vulcan (U) Constant Volume Combustion (CVC) engines have 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 propulsion system capability. CVC engines, when combined with turbine engines, offer the ability to design a new class of Mach 4+ air breathing engines. The goal of the Vulcan demonstration program is to design, build and ground test an engine capable of accelerating a full scale hypersonic vehicle from rest to Mach 4+. Vulcan will leverage technology advances achieved by the ongoing Reusable Combined Cycle Propulsion (RCCP) program's High Speed Turbine Engine Demonstration (HiSTED) effort, which was previously funded from this project and has transferred to the Air Force Research Laboratory in accordance with the DARPA/AF MOA. The Vulcan engine will consist of a CVC engine, a full scale turbine engine, an inlet and a nozzle. CVC engine architectures could include Pulsed Detonation Engines (PDE's), Continuous Detonation Engines (CDE's) or other unsteady CVC engine architectures. The CVC engine would operate from below the upper Mach limit of the turbine engine to Mach 4+. The turbine engine will be a current production engine capable of operating above Mach 2. Key objectives of the program are to integrate the turbine engine into the Vulcan engine with minimal modification to the turbine engine, to operate the turbine engine from rest to its upper Mach limit, and to	2.100	10.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
cocoon the turbine engine when it is not in use. The Vulcan engine will enable full scale hypersonic cruise vehicles for intelligence, surveillance, reconnaissance, strike or other critical national missions. Beginning in FY 2010, this program will be funded from PE0603286E, Project AIR-01. *FY 2008 Accomplishments:* - Developed Vulcan engine conceptual designs. *FY 2009 Plans:* - Complete engine system requirements review. - Identify all technical risks and develop a critical technology development plan. - Develop Vulcan engine performance models.				
Transformer (TX) Vehicle (U) The Transformer (TX) Vehicle program will examine the feasibility and approaches for developing TX vehicles that can fly for two hours carrying a 1 to 4-person payload 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.	.000	.000	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiate preliminary design studies. - Conduct risk reduction experiments and modeling to validate designs.				
Autonomous Aerial Refueling (U) The goal of the Autonomous Aerial Refueling program is to demonstrate the operational feasibility of high altitude refueling between unmanned, limited flight performance aircraft. The program will leverage legacy Global Hawk 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, and complex systems integration. The primary benefit will be to enable 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 also foster a greater acceptance of increased autonomy in challenging battlespaces, and 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. - Begin aircraft modifications. - Validate drogue performance at altitude (single-ship).	.000	.000	8.000	

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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
TT-13: NETWORK CENTRIC ENABLING TECHNOLOGY	55.663	69.588	76.332						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 2008	FY 2009	FY 2010	FY 2011
Automated Battle Management (U) The Automated Battle Management program is developing novel technologies for multi-platform, automated battle management at the tactical level, in the air, on the ground, and within mobile sensor networks. Such technologies are required if U.S. forces are to keep up with the increasing pace of battle as more-capable platforms and higher-bandwidth communication networks become operational. While experienced commanders are required to formulate strategy and select tactics, the increased operational	23.790	9.978	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

tempo will demand more automation of low-level decision processes, such as route-finding, weapon/target pairing, and sensor scheduling. Some elements of these processes, such as collision avoidance and navigation, will be embedded in each platform. However, groups of platforms will be able to execute cooperative tactics to achieve coordinated effects. This cross-platform coordination and synchronization requires new technologies that can carry out aggregate maneuvers and tasks, while leveraging the functions embedded in each platform.

(U) The Collaborative Networked Autonomous Vehicles (CNAV) effort will be the primary demonstration of Automated Battle Management techniques. CNAV will develop 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 will utilize these capabilities to provide submerged target detection, localization, and tracking in restrictive littoral waters. CNAV provides this capability by creating a field of dozens or hundreds of vehicles, networked through acoustic wireless communications. The vehicles work collaboratively and autonomously to detect, classify, localize and track target submarines transiting the field. The field self-organizes to adapt to changes in target locations, environmental conditions, and operational factors. A reach-back capability allows reporting of field health and enables high-level orders and control functions to be provided to the field. CNAV will also result in a significant reduction in the cost per square mile for submerged target detection in littoral waters.

FY 2008 Accomplishments:
- Performed intelligent routing of threat characteristic and track data through the field to alert CNAV nodes down stream to position or reposition for target pursuit and intercept.
- Demonstrated fully autonomous and collaborative CNAV field deployment, autonomous field set-up and self-localization, and distributed common tactical operational picture.

FY 2009 Plans:
- Demonstrate collaborative automated target detection, classification, localization and tracking.
- Demonstrate self-healing and reconfiguration, and threat pursuit and interception.
- Demonstrate autonomous recharging, refueling and field establishments to autonomous field deployment.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Video and Image Retrieval and Analysis Tool (VIRAT)*	7.000	16.241	15.159	

*Formerly Combat Zones that See.

(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 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 2008 Accomplishments:
- Commenced video analysis algorithm development.
- Began development of methodologies for defining descriptors of activities in video and associated indexing and search methods.

FY 2009 Plans:
- Continue developing a set of descriptors for activities in videos.
- Continue developing an efficient indexing method for activity descriptors and an efficient search method against those indices.
- Develop an interactive retrieval process to either alert the user or return to the user matching ‘activities of interest’.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop a system architecture. *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. - 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.				
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. (U) Drawing upon technologies developed in the Home Field program, the Urban Photonic Sandtable Display (UPSD) program develops 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	11.373	12.513	20.578	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

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 (LCDs, DMDs,) and by using LHPDM, it will enable the transmission of larger fractions of light from the illumination source.

FY 2008 Accomplishments:
- Demonstrated the ability to extract architectural features, such as windows and doors, from close-in imagery.
- Built and customized the active hogel modules into tiles and aligned tiles in superstructure for 2-foot by 2-foot and 3-foot by 3-foot systems.

FY 2009 Plans:
- Research advanced technologies for improving the production methods of pixilated emissive displays.
- Demonstrate 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).
- Develop cost effective synthesis methods for Group II-VI and III-V materials.
- Utilize controlled arrays of indium gallium nitride (InGaN) to form high efficiency Light Emitting Diode (LED) structures and imaging sensors in IR.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Assemble layer-by-layer heterostructures (characterized by dissimilar materials with non-equal band gaps) 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 5 times cost reduction potential. - Commence demonstration of fabrication technologies that support the fabrication of 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. *FY 2008 Accomplishments:* - Augmented existing social science models with emerging computational social science models and theories. - Built tools to automatically translate the data corpus into a form usable by quantitative and computational social science models. - Developed new crisis monitoring and forecasting models across multiple timescales and levels of analysis.	13.500	10.608	7.895	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Integrate forecasting model components in a real-time analytical system. - Conduct regular experiments to assess predictions in an operational environment. - Create a rigorous analytic capability to predict how alternative courses of action (COAs) are likely to alter adverse emergent patterns. *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).				
Extreme Accuracy Tasked Ordnance (EXACTO)* *Formerly Laser Guided Bullet. (U) The Extreme Accuracy Tasked Ordnance (EXACTO) program is developing a system that provides sniper teams with the ability to identify and engage targets with heretofore unobtainable range and accuracy against stationary and moving targets under difficult environmental conditions, either day or night. The system uses a combination of 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, and sensors. The components must fit into the limited volume (2cm to the third power) of a 50-caliber projectile and be designed to withstand a high acceleration environment. When integrated and tested, this system will greatly increase the effectiveness of two-man sniper teams, regardless of the environmental conditions and the time of day. The EXACTO technology is planned for transition to the Army by FY 2012. *FY 2009 Plans:* - Design guidance system. - Design maneuverable projectile. - Construct all novel 1x scale components. - Measure component and subsystem performance in appropriate environments.	.000	15.670	19.700	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Demonstrate potential performance using Hardware-in-the-Loop (HITL) simulation (based on measured component and subsystem performance) at a number of ranges under a variety of environmental and target conditions. - Perform initial system integration of all subsystems.				
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 of operations. 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 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 PC. *FY 2009 Plans:* - Design automated media exploitation algorithms for multiple operating systems and file types. - Design integrated exploitation system that produces ranked lists of summarized content found on digital media. *FY 2010 Plans:* - Develop automated media exploitation algorithms that analyze the intelligence value based on content analysis of text files.	.000	2.500	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Integrate algorithms into a digital media exploitation platform capable of producing a human-readable summary of text files. - Demonstrate intelligence extraction by testing digital media.				
Strategic Communication Assessment and Analysis System (SCAAS) (U) The Strategic Communication Assessment and Analysis System (SCAAS) program will develop new theories, concepts, tools and systems to formulate and assess sound strategic communication strategies and measure their effectiveness in influencing allies, adversaries, and other constituencies around the world. Effective strategic communication is central to our ability to effectively deter adversaries, reassure allies, dissuade future competitors, and communicate our resolve to defeat enemies should deterrence fail. The capability developed under SCAAS would have dramatic value to combatant commands as it would enable the influencing of diverse people and organizations abroad towards U.S. National Security interests. *FY 2009 Plans:* - Develop models to continuously analyze/assess the strategic communications "information environment" from multiple perspectives and levels of analysis, including audience, context transmitters, and time. - Develop models for mapping influences to perceptions (such as influences of cultural context, cognitive and emotional biases on message reception and interpretation). *FY 2010 Plans:* - Develop robust analytic methodology to formulate, monitor and assess strategic communication messages and actions, and their contribution toward end-state objectives. - Test and evaluate models and methodologies against several use cases.	.000	2.078	4.000	
PERsistent Surveillance Exploitation and Analysis System (PerSEAS) (U) The PERsistent Surveillance 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. Persistent, wide area surveillance imagery is an ever increasing source of	.000	.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
operational data, but exploitation of this data at present is mostly manual and requires hours to days to produce minimal 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 defeat threats in real-time. Technologies are planned for transition to the U.S. Air Force Distributed Common Ground Station. *FY 2010 Plans:* - Formulate approaches to network discovery based on normalcy estimates, improved tracking algorithms using pattern analysis, and contextual analysis for anomaly detection.				

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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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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	297.030	282.896	268.859						Continuing	Continuing
MBT-01: MATERIALS PROCESSING TECHNOLOGY	186.811	137.333	131.882						Continuing	Continuing
MBT-02: BIOLOGICALLY BASED MATERIALS AND DEVICES	110.219	145.563	136.977						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.

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B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	301.741	285.264	257.799	
Current BES/President's Budget	297.030	282.896	268.859	
Total Adjustments	-4.711	-2.368	11.060	
Congressional Program Reductions	.000	-10.768		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	8.400		
Total Reprogrammings	3.550	.000		
SBIR/STTR Transfer	-8.261	.000		
TotalOtherAdjustments			11.060	

Congressional Increase Details ($ in Millions)

	FY 2008	FY 2009
Project: MBT-01, **Strategic Materials and Silicon Carbide Optics**	.000	4.400
Project: MBT-01, **Synthetic Fuel Innovation**	.000	4.000

Change Summary Explanation

FY 2008
The decrease reflects a below threshold reprogramming action and the SBIR/STTR transfer.

FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and execution delays offset by congressional increases identified above.

FY 2010
Increase reflects enhancements to the Biological Systems project to continue prosthetics and neurological systems efforts.

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APPROPRIATION/BUDGET ACTIVITY	**R-1 ITEM NOMENCLATURE**	**PROJECT NUMBER**
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	PE 0602715E MATERIALS AND BIOLOGICAL TECHNOLOGY	MBT-01

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MBT-01: MATERIALS PROCESSING TECHNOLOGY	186.811	137.333	131.882						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 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated capability to capture salient features of microstructure, converted data into functional entries for physics based model parameters, and demonstrated active reconstruction of microstructure for visualization. - Demonstrated integration with digital microstructural representation in order to illustrate dynamic effects on salient features in response to extrinsic stimuli. - Demonstrated the ability to functionalize, disperse and spin single wall nanotube-containing carbon precursor that could be handled with industrial relevant fiber making equipment. - Demonstrated production of carbon nanotube reinforced graphite fiber at hundreds of meters. - Demonstrated ability to electrospin small diameter precursor tows.	12.000	11.285	7.300	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Designed, built and operated large area lithographic exposure machine subsystems to produce ceramic cores for casting of superalloy turbine blades. *FY 2009 Plans:* - Demonstrate integration of digital microstructural representation, identification of critical features, and physics based models of mechanical behaviors for design of material composition and processing to achieve a set of desired properties. - Demonstrate integration of physics based predictive models of materials performance with digital microstructural representation. - Scale up advanced carbon fiber manufacturing from research line to pilot production line while maintaining properties that are in excess of 1000 Kilos per square inch in strength, 50 Million pounds per square inch in modulus and two percent strain to failure. - Increase nozzle count of the near field electro spinning system to 100 nozzles (from 50) and upgrades of dual coagulation and rinse baths stretching, drying and winding operations. - Demonstrate economical tooling for low volume production of polymer matrix composite (PMC) (10-25 units of a CH-47 helicopter ramp) that operates at less than 200 degrees Celsius cure temperature. - Verify PMC subcomponent (containing critical details) meets static, fatigue, and destructive evaluations. - Demonstrate a technology readiness level of four on full-size manufacturing of non-autoclave PMCs. *FY 2010 Plans:* - Demonstrate ability to scale small diameter tow precursor manufacturing and conversion techniques to full production capacity. - Demonstrate ability to scale Single Wall Nanotube (SWNT) loaded precursor tow manufacturing and conversion techniques to full production capacity. - Demonstrate ability to use fiber as woven mat in pre-preg for composite structures. - Demonstrate carbon fiber properties that are in excess of 1800 Kilos per square inch in strength, 60 Million pounds per square inch in modulus and three percent strain to failure. - Transition non-autoclave tooling and materials/processes to large-scale PMC fabricators.				
Structural Materials and Coatings	12.800	10.000	12.498	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 2008 Accomplishments:* - Developed processing of commercially pure titanium (Ti) from oxide at a production rate of fifty pounds per day. - Demonstrated ten times improvement in fracture toughness for ferrous (Fe) based bulk metallic glasses. - Demonstrated ability to melt and cast fully amorphous calcium (Ca) based metal alloys in large quantities in a production based facility. - Produced aluminum (Al) based amorphous ingots that meet strength and fatigue requirements for use in turbine engine fan blade application. - Demonstrated thermal spray technologies and processes at large scale contractor facility on relevant substrate materials. Thermal spray coatings survived military specification (MILspec) drop tests with no evidence of delamination or cracking. - Developed index matched glass fiber or resin composite systems that can be produced and fabricated into components by conventional composite fabrication techniques. - Demonstrated thin glass laminate materials and structures (fiber loading dependent) with optical transparencies between fifty to seventy-five percent. - Produced and evaluated the efficacy of prototypical shapes (with seams and joints) using transparent composite materials. *FY 2009 Plans:* - Develop processing of commercially pure titanium from oxide at a production rate of 500 pounds per day. - Verify titanium costs are less than four dollars per pound.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Produce solid and hollow sets of aluminum (Al) based amorphous turbine engine fan blades that meet all dimensional and mechanical property requirements. - Construct 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. - Apply Naval Advanced Amorphous Coatings on the Waterborn Mission Zone on Littoral Combat Ship (LCS-1); perform in-field testing and certify coatings for unrestricted use on naval combatants. - Initiate development of regenerative skin to prevent biofouling based upon continuous water activated film formation/dissolution concept. - Establish the conditions necessary to tailor formation and dissolution of the anti-biofouling skin, and their effects on rheological and mechanical properties. *FY 2010 Plans:* - Demonstrate meltless titanium consolidation. - Demonstrate a new alloy that can not be made by conventional processing. - Demonstrate structural amorphous metals in test turbine engines. - Verify integration into fan disk, stability, damage tolerance and coating requirements (if any). - Quantify performance and specific fuel consumption attributes for both military and commercial engines. - Demonstrate coatings of structural amorphous metals fan blades to address galling and environmental requirements. - Demonstrate dual functionality of structural amorphous metals/composite hybrid structures for space. - Demonstrate ability to delay the formation of persistent shear bands from vein structures that lead to crack initiation on a materials surface due to prolonged fatiguing by using magnetic fields in multiple alloy systems, including steels, aluminum (Al), titanium (Ti), and nickel (Ni) based alloy systems. - Determine approximate number of cycles for given loading conditions needed to form veins and subsequent persistent shear bands in order to formulate treatment cycle schedule for various alloy systems. - Identify multiphase composite materials suitable for use at high temperatures. - Determine volume fraction, distribution and morphology to obtain optimum structural properties.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Determine the effectiveness of the anti-biofouling skin against selected organisms in marine test environments having various hydrogen (pH), salinity and temperature. - Demonstrate circulatory and injection system for the generation of anti-biofouling skins over a significant area (greater than one square foot). - Hybrid multi-material characterization and process development. - Multi-physics computational tool development.				
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 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, and improve the survivability of space structures. *FY 2008 Accomplishments:* - Demonstrated continuous processing and control of nano-textured polymer and glass powder superhydrophobic surfaces at rates up to 2.9 square meters per hour (m/hr). - Produced carbon nanotube based cold cathode for use in ionic thrusters with current density on the order 1800 microampere per centimeter squared (order of magnitude increase in performance over off-the-shelf ionic thruster cathodes). - Demonstrated dramatic increases in cavitation resistance, corrosion resistance, surface hardness and fatigue resistance of IN718 (nickel based super alloy), A286 (austenitic ferrum based super alloy) and SAF2205 (duplex stainless steel) for use on combat ship propulsors without degrading bulk mechanical properties. - Developed flexible and lightweight surface wave controlling and power transmitting media that binds surface waves to within 1 millimeter of the surface, transmits data at greater than 36 megabits per second (Mbps) and transmits power at greater than 300 watts (W). - Began to investigate new membranes and technologies for particle separation to reduce the clogging and fouling of desalination systems.	12.200	10.100	12.700	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Demonstrate robust adherence of glass coating and textured polymer in order to produce superhydrophobic surfaces on various substrates. - Increase carbon nanotube (CNT) cold cathode performance to 4000 microampere per centimeter squared by demonstrating ability to grow multi-wall nanotubes decorated with gallium nickel (GaN) for increased field emission properties. - Demonstrate reduced scattering and losses due to perturbations and damage that might occur on surface wave controlling and power transmitting media. - 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. *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. - Demonstrate functional field emission device using CNT cold cathodes within commercially available Hall effect thruster body. - 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.				
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.	13.300	11.929	15.200	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated improved ballistic performance with reduced weight as compared with rolled homogeneous armor areal density. - Integrated high performance armor systems onto vehicle platforms in collaboration with the U.S. Army and Marine Corps. - Reduced the cost of hybrid composite armor systems with high throughput manufacturing techniques and by exploiting the benefits of commercial materials. - Demonstrated transparent armor systems with improved ballistic performance and reduced the size of the damage zone. - Demonstrated the importance of shock wave mitigation and projectile tipping mechanisms. - Developed topological armor concepts for explosively formed projectile (EFP) defeat. *FY 2009 Plans:* - Develop lightweight armor systems to mitigate and defeat evolving threats, including EFPs. - Evaluate topological armor concepts for protection against multiple threats. - Optimize transparent armor for fragmentation and armor piercing threats. - Integrate 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. - Demonstrate protective abilities of novel topological armor against EFP threats. - Demonstrate advanced technologies for mitigating EFP derived projectiles. *FY 2010 Plans:* - Demonstrate capability for production of index-matched fiber for transparent armor systems. - Demonstrate interface control of fibers with transparent polymers. - Demonstrate ballistic performance of spinel/index-matched polymers against armor piercings and fragment simulating projectiles. - Establish model for performance of transparent armor systems.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Demonstrate multi-hit capability of lightweight, mass producible armor. - Understand the defeat mechanisms against blast and fragment penetration to vehicle underbodies as a function of specific layering combinations of composite and metallic materials. - Evaluate the effectiveness of high-strength materials with respect to stiffness, shock isolation, and energy absorption. - Identify the most effective topological features for energy absorption and understand how material and system-level performance can be optimized at a minimum system areal density.				
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. *FY 2008 Accomplishments:* - Demonstrated predictive capability of Structural Integrity Prognosis System (SIPS) in predicting the capability and structural life of EA6B aircraft outer wing panel in independent tests on actual wings carried out by NAVAIR on actual hardware. - Identified sensor suites reasoner architecture for SIPS applied to the P3 aircraft. - Identified high-usage P3 aircraft and established agreement with P3 Class Desk for a one year flight test program to validate SIPS in actual aircraft operations under severe operating conditions. - Initiated test for flight operations. *FY 2009 Plans:* - Complete and provide 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).	10.000	3.000	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Transition to Air Force Materiel Command. - Demonstrate ESP system on the T700 helicopter engines with specific objective of real time “power available” notification to the pilot. *FY 2010 Plans:* - Initiate complete system analysis for Air Combat Command (ACC) and Air Mobility Command (AMC) legacy aircraft. - Identify sensor requirements and establish virtual sensor logic for parameters not easily measured. - Characterize key materials of interest (metal and composite) and identify damage accumulation mechanisms. - 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.				
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 2008 Accomplishments:* - Performed laboratory testing of modulated chemical systems to assess transmission properties including range. - Began to define fundamental trade space for spatial control and destabilization of flame plasmas. - Initiated development of materials that integrate structural integrity and high performance energetics into the same composite material to create multifunctionality in munitions cases thereby enabling substantial increase in performance/reduction in size. - Initiated investigation of methods to control, at the mesoscale, conversion of mechanical to thermal energy in composite systems. - Demonstrated spanwise blade twisting on a representative rotor set.	15.540	15.370	11.025	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Fabricated, tested, and assessed silent maneuver capability of a nastic skin array on a scale model submersible. *FY 2009 Plans:* - Refine chemical systems to achieve 100-fold increase in transmission duration. - Engineer prototype chemical communications devices consisting of a disposable transmitter and a replicator device, with the form factor of a personal digital assistant, which translates messages into chemistry. - Perform field testing of prototype chemical communications devices. - Laboratory demonstration of fire suppression/manipulation approach, for Class A/B fires. - Conduct rotor stand test of fully actuated one-third scale prop rotor to demonstrate blade synchronization and lift improvement. - Experimentally evaluate combustion driven nastic materials actuator for innovative acoustic applications. - Design material composites that are both high density and highly energetic. - Develop and demonstrate processing methods to increase strength of dense reactive metal composite materials. *FY 2010 Plans:* - Develop prototype fire suppression system, and perform field demonstration for simulated ship hold fire. - Develop methods to rapidly decompose reactive metal composite materials. - Demonstrate the ability to control particle size. - Demonstrate the ability to control dispersion as a function of particle size. - Develop and demonstrate the ability to activate reactive components within composite material. - 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.				
Reconfigurable Structures	11.300	9.700	12.646	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 to adapt optimally to changing mission requirements and unpredictable environments. This includes the demonstration of a morphing aircraft as well as new materials and devices that will enable the military to function more effectively in the urban theater of operations. *FY 2008 Accomplishments:* - Developed soft chemically based materials with the ability to drastically change shape, reconfigure, and perform designated functions. - Formulated general theoretical model for reversible adhesive traction of chemical robots on terrain. - Demonstrated jamming transition which reversibly transforms rigid solid objects into free-flowing particulate matter for aperture traversal. - Elucidated materials dynamics of hyper-flexible caterpillar for translation into synthetic materials. - Demonstrated adhesion repeated 100 times on glass, aluminum, and brick under both wet and dry conditions on a four inch by four inch pad. - Determined proper climbing techniques via biomechanical analysis for maximum rate of climb, moving laterally, and descending using the required attachment-removal-reattachment kinematics. *FY 2009 Plans:* - Engineer soft components from the soft chemically-based materials that enable locomotion and size/ shape morphing. - Engineer 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. - Engineer soft payloads with the ability to both traverse openings smaller than their characteristic dimension, and perform work. - Integrate soft payloads into robotic architecture. - Design, refine and finalize pads for hands and feet based upon results of biomechanical analysis and human climbing trials. - Demonstrate an unloaded soldier (150 lb) scaling a series of twenty-five foot walls built from mission relevant materials.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Perform laboratory testing of robot operation 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) scaling a series of twenty-five foot walls built from mission relevant materials.				
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 2008 Accomplishments:* - Designed an optical negative index material based modulator for improved optical communications. - Designed a sub wavelength ultra high frequency (UHF) antenna. - Demonstrated delay of 10 gigabits per second optical data stream by more than 75 nanoseconds, and incorporated tunable delay into reconfigurable time-based multiplexer. *FY 2009 Plans:* - Demonstrate a low loss, negative index enabled optical modulator with reduced size and increased speed for military communications. - Demonstrate a sub wavelength UHF antenna with enhanced efficiency for military radar and communication applications. - Demonstrate delay of 40 gigabits per second data stream by more than 1 micro-second, and incorporate tunable delay into reconfigurable optical data buffer. - Demonstrate slow light based compact optical interferometer with greater than three times reduction in optical path length.	10.000	4.871	10.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Design ultra violet light source with thirty times improvement in average power output. - Design laser-plasma source for collimated proton/ion beam with output energy greater than 10 mega electron volts (MeV). - Demonstrate, in a laboratory environment, a low power room temperature magnetic sensor with a sensitivity of 100 femtotesla root mean square (rms) per square root hertz (or 10 to the minus 13 tesla rms per square root hertz). - Demonstrate a 10 x 10 array of magnetic sensors with an overall sensitivity of 1 picotesla rms per square root hertz at a frequency of 1 Hertz. - Investigate materials to exchange oxygen and carbon dioxide at the high flux rates necessary for performing underwater missions. - Investigate carrier materials to transport oxygen and carbon dioxide at the saturation levels required for performing underwater missions.				
Power Components (U) This thrust explores and develops novel components for use in diverse power systems that will dramatically increase the 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 2008 Accomplishments:* - Initiated development of nano-structured materials that can achieve improved thermoelectric properties. - Initiated development of nano-structured magnetic materials with improved energy product. - Initiated development of nano-structured electrochemical materials with improving energy and power density.	9.100	8.000	9.200	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Developed nano-structured materials and demonstrated the ability to improve thermoelectrics with figures of merit approaching 2.0, magnetics approaching two times current energy product and batteries with 500 watt hours per kilogram (Wh/kg) energy density. - Developed new ceramic and polymer dielectric materials with high permittivity, high breakdown strength and high temperature (greater than 200 degrees Celsius) operation. *FY 2009 Plans:* - Incorporate new dielectric materials into a high energy dense capacitor to achieve 20 joules per cubic centimeter (J/cc) energy density and 100 joules (J) of power. - Demonstrate synthesis of nanocomposite thermoelectric materials with figures of merit greater than two for low, medium and high temperature ranges. - Demonstrate synthesis of nanocomposite magnetic structures with two times energy product. - Demonstrate synthesis of nanocomposite electrochemical materials with power densities approaching 2000 watts per kilogram. *FY 2010 Plans:* - Integrate nano-structured thermoelectric materials into effective structure for military use. - Integrate nano-structured magnetic materials with high energy product into military motor. - Integrate nano-structured electrochemical materials with high energy and power densities into military battery supplies. - Innovatively package the 20 J/cc dielectrics into capacitors with sensing capabilities to provide reliable high power capacitors of 20 J/cc and 400 J. - Design and build system that will transfer power wirelessly with greater than twenty percent efficiency at ranges of up to 10 meters and at ranges up to 1 kilometer. - Demonstrate proof of concept for nano-gap device with an efficiency greater than 8 percent at a temperature difference of 200 degrees C.				
Novel Power Sources (U) The Novel Power Sources thrust will explore new materials solutions to enable power to be efficiently generated and controlled. This includes new materials concepts to increase the efficiency and robustness	9.650	4.000	6.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
of portable fuel cells as well as the exploitation of nanotechnology to increase the efficiency and lower the weight of batteries. A related focus is new catalytic materials and processes for alternative energy sources that are compatible with military logistic fuels. An additional focus is to develop materials to drastically improve the efficiency of low temperature thermoelectric components and develop these components into demonstration systems. *FY 2008 Accomplishments:* - Demonstrated high energy density power sources that enable Unmanned Air Vehicle (UAV) and Unmanned Ground Vehicle (UGV) mission durations that are five times longer than current state-of-the-art batteries allow. - Initiated the development of catalysts powered by sunlight for reducing carbon dioxide and water into syngas (carbon monoxide and hydrogen). - Initiated quick and efficient conversion of cellulosic and lignin biomass into a synthetic fuel with eight carbons or more using chemical catalysts. - Initiated the next generation of fuel cells capable of running on JP-8 without degrading due to coking and sulfur poisoning through the use of novel surface catalysts. *FY 2009 Plans:* - Demonstrate the use of extruded membrane within existing solid oxide fuel cell architecture to operate using JP-8 fuel. - Demonstrate efficiencies of surface catalysts for cogeneration of carbon dioxide and hydrogen powered by sunlight. - Develop 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.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Integrate new catalysts for highly efficient alternative energy systems including fuel cells, biomass conversion systems, and solar fuel systems.				
Very High Efficiency Solar Cell (VHESC)	17.500	21.000	6.600	

(U) The objective of the Very High Efficiency Solar Cell (VHESC) program is to demonstrate at least fifty percent efficiency in an affordable, manufacturable photovoltaic (PV). This technology breakthrough will provide soldiers with portable power for electronic devices resulting in a dramatic reduction in the complex logistics associated with delivering batteries to troops in the field, while improving mission endurance and individual soldier agility. It will also provide the DoD with a fixed terrestrial renewable energy source.

(U) The program addresses all aspects of the high-efficiency PV 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 photovoltaic devices and 2) the development of high-volume cost-effective manufacturing engineering designs and processes for the subsequent future transition to affordable production.

FY 2008 Accomplishments:
- Demonstrated an integrated proof of concept module with greater than forty percent efficiency.
- Demonstrated potential cost reduction technologies supporting cost scaling in large scale production.

FY 2009 Plans:
- Design, build and test VHESC engineering prototype modules addressing the program goals.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop technologies to reduce the costs of the photovoltaic cells and optical components. *FY 2010 Plans:* - Deliver an initial integrated prototype.				
Alternate Power Sources (U) The aim of the Alternate Power Sources thrust is to develop materials and technologies to utilize alternative power sources that have the potential to provide significant strategic and tactical advantages to the DoD. The thrust is very diverse, and includes the development of portable power platforms that efficiently (greater than ninety percent) utilize military waste materials (plastic and paper) for generation of electricity, as well as the development of agricultural plastics that are optimum for electricity generation in these platforms. Very small volume (less than one cubic millimeter) rechargeable micro-batteries with maintained energy density comparable to conventional lithium ion batteries will be developed. *FY 2008 Accomplishments:* - Scaled up 5 kilowatt Mobile Integrated Sustainable Energy Recovery (MISER) process to 60 kilowatt electric generator. - Demonstrated use of mixed plastics and paper as fuel for MISER system. - Improved synthesis (0.5 gallons per liter hour (L/hr)) and polymerization processes for high energy recoverability polymers. - Developed packaged battery of less than 6 cubic millimeters that possessed an energy density of greater than 200 watt hours per liter (Wh/L). - Simulated molecular dynamics of helium-xeon gas mixtures in a collapsing bubble that predicted segregation of helium to the center of the bubble during sololuminescence experiments and produced temperatures as high as 100 million degrees Kelvin, much higher than either helium or xeon alone. - Established the effects of surface area and crystal orientation on degree of deuterium loading and the loading/relaxation dynamics. Correlated these effects with increases in generated excess heat. - Demonstrated ability to control palladium substrate composition, grain structure, and surface morphology conditions, and reliably generated significant excess heat.	9.120	4.707	1.813	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Further improve packaging and electrode architectures to maintain packaged battery energy density goals of greater than 200 Wh/L, in a volume of less than 1 cubic millimeter. *FY 2010 Plans:* - Continue to improve packaging and utilization of active electrode materials to manufacture a packaged battery with an energy density greater than 350 Wh/L in a volume less than 1 cubic millimeter.				
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 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 2008 Accomplishments:* - Designed, developed, and demonstrated a process pathway for greater than sixty percent conversion (by energy) of crop oil to JP-8. - Elucidated a path to ninety percent conversion of crop oil to JP-8. - Identified technology pathways for the conversion of a broad diversity of cellulosic, algal, and other similar feedstocks to affordable bulk quantities of JP-8. - Developed three processes for crop oil conversion to JP-8. - Produced JP-8 which successfully passed Air Force Research Laboratory military specifications (MILSPECS). - Identified a multitude of feedstocks for conversion to JP-8.	29.500	13.600	23.900	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Demonstrated the scalability of production technologies for the affordable conversion of crop oil to JP-8 at a cost of greater than five dollars per gallon. *FY 2009 Plans:* - Identify and select 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. - Demonstrate the conversion of cellulosic materials to JP-8 range alkanes with greater than thirty percent efficiency (by energy). - Identify a pathway for the conversion of cellulosic materials to JP-8 range alkanes with greater than fifty percent efficiency (by energy). - Identify 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. - Identify 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. - Explore the size and volume efficiency scaling relationships for various processing technologies for converting indigenous materials to JP-8 and other liquid fuels. - Develop 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.				
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 is exploring the breakthroughs in power generation needed for extremely long duration, unmanned applications including unmanned underwater vehicles (UUVs) and unmanned air vehicles (UAVs). These include energy storage approaches that are structurally efficient as well as energy efficient. It also includes approaches for	5.001	1.371	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
efficiently removing the energy at rates commensurate with the high sprint power often required in these applications. Products will transition to the Navy in FY 2009/2010. *FY 2008 Accomplishments:* - Continued development of the direct carbon fuel cell. - Laboratory demonstration of solid oxide fuel cell technology achieved program goals for power density, fuel utilization, and lifetime metrics. *FY 2009 Plans:* - Full scale laboratory demonstration of solid oxide fuel cell/battery power system for a thirty day large scale UUV mission.				
Strategic Materials (U) This program will investigate strategic materials. *FY 2008 Accomplishments:* - Optimized the process for reliable, robust, repeatable, and cost effective Chemical Vapor Composite (CVC) silicon carbide (SiC) manufacturing process for high tech military, space, and industrial applications. *FY 2009 Plans:* - Continue CVC SiC process development. - Demonstrate bonding and integration of CVC SiC assemblies.	5.000	4.400	.000	
Economic Production of Coal-to-Liquid Fuels (U) This program researched the economic production of converting coal fuels to liquid fuels. *FY 2008 Accomplishments:* - Researched the economic production of converting coal fuels to liquid fuels.	2.400	.000	.000	
Reduce Environmental Impact of Coal-to-Liquid Fuels	2.400	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) This program researched ways to reduce the environmental impact of converting coal fuels to liquid fuels. *FY 2008 Accomplishments:* - Researched ways to reduce the environmental impact of converting coal fuels to liquid fuels.				
Synthetic Fuel Innovation (U) This program will research innovative techniques for the development of synthetic fuels. *FY 2009 Plans:* - Research innovative techniques for the development of synthetic fuels.	.000	4.000	.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 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 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	110.219	145.563	136.977						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 magnetic 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 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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. This thrust also includes efforts to develop bioinspired swimming aids that will increase the speed and reduce the metabolic costs for combat divers, and make current devices (fins) obsolete for most tactical scenarios. *FY 2008 Accomplishments:* - Demonstrated mobility and range capability in a militarily relevant environment by traversing five miles of wooded terrain while following a human lead. - Demonstrated dynamic climbing on vertical terrestrial features. - Fabricated sixty oscillating foil devices followed by operational validation; transitioned to the military user.	6.700	1.000	1.500	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Establish adaptive materials and controlled devices for biped locomotion. *FY 2010 Plans:* - Demonstrate 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 Plans:* - Investigate new methods of biotemplating and biocatalysis with biological materials (i.e., microtubules, filamentous viruses, peptides, bacteriophages) to facilitate new sensors and devices. - Develop 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.	.000	1.000	2.000	
Bioinspired Sensors (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	17.233	12.900	23.300	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Completed a series of investigations into bioinspired materials and sensors (e.g., visual, auditory, olfactory, gustatory and tactile) to examine unique characteristics for future sensor designs. - Designed novel sensor technologies, including a prototype vision sensor based on the properties of the mammalian retina for the creation of high dynamic range sensor capabilities, and tactile sensors for novel situational awareness in robotic platforms. - Described components for a sensitive, but flexible olfactory system built from and inspired by the structure and components of the mammalian olfactory system. - Identified methods for high throughput generation of odorant molecules of interest and stable expression of receptor proteins in a cell-based system. *FY 2009 Plans:* - Develop breadboard olfactory system, with emphasis on chip-based, non-cellular expression approaches for detection of relevant odorant molecules. - Demonstrate rapid detection of defined odorant molecules through the olfactory receptor-based breadboard system. - Develop method for rapid synthesis of odorant receptors not previously expressed in the system. - Conduct a design review of breadboard olfaction systems; test and evaluate all approaches simultaneously at an independent testbed. *FY 2010 Plans:* - Develop brassboard olfactory system(s) based on successful previous designs. - Demonstrate the brassboard's ability to detect twenty-five individual odorants/chemicals, with a portion contained in a chemical mixture.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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. - Evaluate successful brassboard systems in a final design review for size, weight, power and performance needed in prototype systems. Select design to move forward to prototype. - Understand requirements for optical device capable of reading single neuron motor signals. - Design and begin development of device prototype.				
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, the molecular correlates of muscle fatigue and psychological stress, and natural resistance to disease through dietary nutrients. *FY 2008 Accomplishments:* - Identified genetic indicators of acute mountain sickness and developed approaches to improve cardio-pulmonary function at high altitude. - Demonstrated greater than forty percent improvement from preconditioning prior to high altitude exposure in murine model.	7.101	6.463	7.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Identify mechanisms to alleviate high altitude illness. - Investigate mechanisms to speed natural acclimatization at high altitudes. - Demonstrate the following in-vitro: mechanisms to increase pulmonary blood flow; methods to increase number of red blood cells; and mechanisms to increase oxygen delivery to muscles. - Position product for use in an FDA Phase I clinical trial by the end of first program phase. *FY 2010 Plans:* - Increase speed acclimatization by providing high altitude cues prior to ascent. - Identify physical adaptation strategies of altitude-adapted people. - Demonstrate high altitude illness prevention in mammals using adaptation strategies of altitude-adapted people.				
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 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 2008 Accomplishments:* - Initiated system-level preliminary design of a prototype soldier-portable digital imaging visual threat cueing system capable of improving current effective detection ranges while simultaneously surveying wide field of view.	9.500	21.400	13.800	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Evaluated methodologies for inclusion of wide angle optics, large pixel count digital imagers, cognitive visual processing algorithms, brain-derived target detection signatures and low power analog-digital hybrid electronics. - Demonstrated first generation closed loop cognitive device with an integrated cognitive-neural subsystem. - Demonstrated cognitive algorithm performance on image streams generated by breadboard imager, with high likelihood of threat detection. *FY 2009 Plans:* - Demonstrate single path (twenty degree by twenty degree) advanced optics on a breadboard system in a field environment consistent with objective performance and package volume. - Demonstrate human-in-the-loop integration with the breadboard system, harnessing non-invasive neural signatures for threat detection. - 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 sixty seconds of scan time. - Demonstrate composite software system capable of high fidelity threat detection with extremely low false alarm rates. - Test breadboard performance in two operational test locations – Yuma Proving Ground and East Range, Hawaii. *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 metrics.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Evaluate device packaging approaches with the knowledge of ruggedization and robustness required for soldier-portable tactical electronic devices. - Complete final optimization of the brassboard components and subsystems.				
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 a neuromorphic vision system. *FY 2008 Accomplishments:* - Completed scaling studies for design of a complete system prototype for biological visual pathway capabilities. - Developed small-scale floating point gate array (FPGA) emulation to test integrated circuit design and demonstrate initial neuromorphic properties of the early visual pathway. - Demonstrated advanced algorithms for visual pathway functionality (saccade, foveate and basic object recognition) on software testbed and validated using topological analysis techniques. *FY 2009 Plans:* - Create neuromorphic FPGA emulation for use as a tool to test advanced algorithms developed by computer vision community. - Develop novel integrated circuit design for the replication of specific visual pathway functions. - Fabricate and complete functional test of a neuromorphic application specific integrated circuit (ASIC) for emulation of basic mammalian visual pathway functionalities.	8.300	9.000	10.500	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Design next generation ASIC with enhanced visual function capabilities for object recognition. - Test new integrated circuit design in FPGA emulation for desired visual pathway performance. - Fabricate and complete functional test of a neuromorphic application specific integrated circuit (ASIC) for emulation of entire mammalian visual pathway, through object recognition. - Evaluate device packaging approaches with the knowledge of ruggedization and robustness required for airborne unmanned systems.				
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 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 2008 Accomplishments:* - Demonstrated an in vitro delivery system that releases a therapeutic dose of a pain drug based on a chosen biological signal and that the release of the drug can be “shut off” when a biomarker for toxic effect is present. - Demonstrated non-toxicity of drug delivery system materials using cultured mammalian cells.	16.200	17.500	10.377	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Demonstrated in vivo studies of the drug delivery system for demonstration of drug activity without overdose toxicity. - Developed algorithms for bleeder detection, localization, coagulation, and cuff control; validated algorithms with in vitro model; integrated algorithms with hardware into a complete system. - Developed new lightweight fiber-optic sensor to provide real-time tracking information for bleeder. - Developed new capacitive micromachined ultrasound transducer technology and high-voltage application specific integrated circuit technology to reduce system weight. - Stimulated expression of three gene markers of blastema development at non-regenerating wound site in a mammal using bone morphogenetic protein-2 (BMP-2). - Demonstrated greater than twenty percent reduction in scar tissue formation associated with BMP-2-induced blastema formation at tissue wound site. *FY 2009 Plans:* - Initiate in vivo studies of the drug delivery system in live experimental models. - Determine optimal scaffold properties that support induction of pluripotent stem cell-like state from scaffold immobilized fibroblast scar cells. - Determine bone morphogenetic protein-2 (BMP-2) responsive cells and the spatial-temporal kinetics of BMP-2-induced blastema formation at tissue wound site. - Demonstrate blastemal associated initiation of early joint formation at appropriate site during healing. - Design and build 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. - Conduct in vivo and in vitro experiments to determine the effect of physiological variables on the deep bleeder acoustic coagulation (DBAC) algorithm. - Develop and test automated algorithms for bleeder detection, localization, coagulation, and cuff control and integrate into a 2.4 kg prototype cuff. - 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.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 BMP-2-induced long bone restoration. - Demonstrate hemostasis in less than four minutes on a high-pressure non-compressible injury model. - Maintain hemostasis in high pressure model for three hours. - Build and demonstrate an automated fieldable prototype DBAC system that operates on batteries. - Optimize automated algorithms for bleeder detection, localization, coagulation, and cuff control with in vivo models.				
Trauma Pod (U) New approaches are necessary to deliver life-saving medical care on the battlefield. Research has demonstrated that several functions that currently take place in an operating room can be automated, such as tool and supply handling. Furthermore, these functions can be conducted faster and more effectively by autonomous machines making it possible to move these functions onto the battlefield. Developing the capability to perform autonomous diagnosis will assist the medic in determining the type and extent of the injury. Innovative procedure modules, imaging and surgical techniques, and a portable tactical platform will allow patient stabilization and provide precious additional time for transport to the combat support hospital. *FY 2008 Accomplishments:* - Developed portable oxygen generator for integration into on-board ventilator system. - Miniaturized and field-certified ventilator system for potential integration into final robotic resuscitation and evacuation system. - Conducted initial studies on the usefulness of heat shock proteins as an immediate therapy for protecting wounded warfighters from adverse effects of shock and other combat related injuries for inclusion as an immediate therapy for evacuated patients.	11.700	12.000	15.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Develop and test additional fully automated surgical techniques including opening of an airway and insertion of an intravenous line (IV). - Design an integrated system capable of treating pneumothorax, internal hemorrhage, and head trauma. - Demonstrate proof of principle imaging and surgical techniques on material surrogates for human tissues and animal models. *FY 2010 Plans:* - Integrate imaging and surgical modules into a portable tactical platform and test overall system. - Demonstrate imaging and automated imaging diagnosis of a tension pneumothorax, intracerebral bleeding, abdominal bleeding, and retroperitoneal bleeding in an animal model. - Demonstrate surgical techniques of an airway on an anatomical model, and insertion of an IV, relief of tension pneumothorax, and control of internal bleeding on an animal model. - Demonstrate scalability of system.				
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 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 2008 Accomplishments:* - Demonstrated plasma-initiated million-fold reduction in bacterial count and 99.9 percent inactivation of bacterial spore population on artificial skin surfaces. *FY 2009 Plans:* - Investigate bacterial and spore population reduction inside catheter structures. - Determine plasma dose required for million-fold reduction in bacterial population for exposed animal wound model.	1.500	2.900	9.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Develop skin (dermis & epidermis) construct of size/shape to match bone constructs. - Demonstrate functional repair of denervated muscles using acellular nerve scaffolds. - Scaffold-based differentiation of salivary gland cells with production of amylase. - Demonstrate computer-aided design production of sinus mucosa construct of size/shape to match patient anatomy. - Design plasma-based bandage for wound treatment based on dose response curves from animal wound models. - Develop and perform safety studies to determine effects of plasma dose on mammalian cells. - Design catheter incorporating plasma-based sterilization of insertion wound and of interior catheter lining. - Perform in vitro studies of plasma effects on viral 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 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, molecular targets for the restoration of long term memory using micro-ribonucleic acids (mi-RNA) will be tested in animal models for their efficacy following stress and training; new approaches to 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	2.000	17.800	16.700	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated the usefulness of a neural signature-based triage system to dramatically increase visual throughput to imagery analysts with no loss of target detection accuracy. - Demonstrated the ability of neural signatures to reveal targets in both overhead electro-optical imagery and synthetic aperture radar imagery. - Integrated imagery triage approach and neural signature processing into the imagery analyst footprint, including integration with baseline software and hardware exploitation environment. *FY 2009 Plans:* - Demonstrate two-fold improvement on specific military learning tasks utilizing neuroscience-based accelerated learning techniques. - Investigate task-independent methods for accelerating learning, including improvements to working memory, attention, and engagement. - Determine the stability of neural signatures in complex imagery conditions, including imagery sources and target types. - Initiate controlled operational tests to demonstrate utility of neural signatures in imagery analysis environment to motivate potential transition interest. - Demonstrate applicability of neural signature-based triage for specific analyst derived concept of operations including broad area search. *FY 2010 Plans:* - Evaluate optimal delivery methods of mixtures of short nucleotide sequences for long-term memory enhancement. - Demonstrate a 10x improvement in long term memory performance thirty days after training, using short nucleotide sequences administered in a single animal model prior to training.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop a comprehensive quantitative description of the impact stress has on the brain, including neurophysiological, cognitive and behavioral measures. This includes understanding the processes by which certain individuals are resilient to the negative effects of stress, understanding how to prevent deleterious effects of stress exposure without blocking the biological and behavioral responses necessary for survival. - 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. - 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, while validating utility of neural signature inputs into imagery workflow. - Determine how functional magnetic resonance imaging (fMRI) can be used to identify intent (gold standard). - Demonstrate that electroencephalography (EEG) can provide intent - information equivalent to fMRI.				
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 allows us to appreciate 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 we seek to better understand anatomical, functional and cellular level interactions. The advanced development of these tools will provide a formidable arsenal of diagnostic tools for warfighter performance and care.	3.530	4.500	7.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Demonstrated a new transmission anode X-ray source having 1.2 times higher yield and efficiency and 6 times greater vertex angle than conventional reflection anode X-ray tubes, enabling ultra-compact computed tomography (CT) imaging for battlefield applications. *FY 2009 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. - Start development of a sealed transmission anode X-ray tube having enhanced vertex angle performance (40 degrees) with 2.5 times higher yield and efficiency, and the ruggedness and lifetime characteristics of a conventional sealed X-ray tube. - Start development of an anode test platform, cathode, and high voltage generator for the sealed transmission tube. *FY 2010 Plans:* - 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. - Demonstrate geographic tracking of disparate events in physical and temporal space.				
Revolutionizing Prosthetics (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	23.955	24.800	15.000	

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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 2008 Accomplishments:* - Performed testing and evaluation required for initiation of clinical trials. - Designed and manufactured prototype limb including biomimetic articulation, longevity of power consumption, and strength and weight that emulate form, function, and response of natural biological limbs. - Developed and demonstrated a clinical prototype virtual integration environment. - Initiated clinical testing of initial limb prototype on combat amputees at military medical centers. - Developed strategies and technologies for commercial manufacture. *FY 2009 Plans:* - Integrate sensory feedback into prosthetic devices. - Evaluate sensory feedback in patients with targeted neural re-implantation. - Complete design of chip for transmission of central nervous system motor signals. - Evaluate chip in experimental models. - Demonstrate the ability to implement brain/neural control with sensor feedback in a control architecture that combines the kinetics and mechanics (degrees of freedom) of natural movement, including the realization of proprioception and reflex. - Develop clinical protocol for testing of four-year prosthetic devices at military medical centers. - Initiate manufacture plan consistent with Good Manufacturing Practices (GMP). *FY 2010 Plans:* - 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.				

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- 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.				
Biodemilitarization of Munitions (U) Based on results from the External Protection Program in PE 0602383E, Project BW-01, the Biodemilitarization of Munitions program will develop a system for rapid, safe, and effective inactivation of explosive munitions stockpiles in place. If these stockpiles can be removed, the raw materials for constructing improvised explosive devices will be greatly reduced. Chemical and biological technologies and control processes will be developed to alter the explosive fill and enable long-term storage and high-reliability inertion of munitions. *FY 2008 Accomplishments:* - Developed two new methods for penetration of steel munitions that do not require mechanical cutting. - Developed mathematical models that characterize the scaling of these technologies for shells of diverse composition and thickness. - Developed and field tested two new methods (catalytic chemical and electrochemical reduction of the nitrated materials) for in-situ deactivation of composition B explosive (trinitrotoluene (TNT) + trinitramine (RDX)). - Integrated penetration, excavation, and remediation of composition B explosive fill of a 155mm M105 artillery round. *FY 2009 Plans:* - Design, develop, and test solid-state transformation processes. - Conduct a Preliminary Design Review for a demonstration system. - Conduct sensitivity testing to determine intermediate and final inertion products to include yield testing in chamber. - Engineering optimization and testing of integrated system against a cache of fifty munitions. - Transition technology to Army.	2.500	4.300	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Blood Pharming	.000	10.000	5.300	
(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 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 Plans:* - Develop 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. - Demonstrate greater than or equal to two million-fold expansion from progenitor source to mature RBC. - Identify at least three stage-specific cell properties (size, shape, biomarker expression) that support automated culture. - Demonstrate normal RBC function (oxygen binding/release, enzyme content, size, deformability) in vitro. *FY 2010 Plans:* - Demonstrate production of 100 RBC units per week for eight weeks in an automated closed culture system using a renewing progenitor cell population. - Demonstrate two hundred million-fold expansion of progenitor population to mature RBCs.				

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**		**DATE:** May 2009
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D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	181.321	199.396	223.841						Continuing	Continuing
ELT-01: ELECTRONICS TECHNOLOGY	181.321	199.396	223.841						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 electronic components, subsystems, and design tools that enable a wide range of military capabilities.

(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. This also includes semiconductor device design and fabrication techniques, new materials and new 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 advances in Transition density within microelectronic integrated circuits 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, novel/alternative materials, new architectures to utilize 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, photonics processing and computing; and new circuit, computer and electronic systems architectures. Projects will investigate the feasibility, design, and development of powerful information technology devices and systems using approaches to 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 (MEMS), Architectures, and Algorithms. Other core research will be pursued to ensure state-of-the-art military capabilities.

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B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	196.707	211.457	229.195	
Current BES/President's Budget	181.321	199.396	223.841	
Total Adjustments	-15.386	-12.061	-5.354	
Congressional Program Reductions	.000	-16.741		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	4.680		
Total Reprogrammings	-10.000	.000		
SBIR/STTR Transfer	-5.386	.000		
TotalOtherAdjustments			-5.354	

Congressional Increase Details ($ in Millions)

	FY 2008	FY 2009
Project: ELT-01, **3-D Technology for Advanced Sensor Systems**	.000	1.440
Project: ELT-01, **Indium Based Nitride Technology Development**	.000	3.000
Project: ELT-01, **Secure Media and ID Card Development**	.000	.240

Change Summary Explanation

FY 2008
Decrease reflects the AFRICOM reprogramming and SBIR/STTR transfer.

FY 2009
Decrease reflects reductions for Section 8101 Economic Assumptions and new starts.

FY 2010
Decrease reflects minor rephasing of electronics technology programs.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**		**DATE:** May 2009
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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
ELT-01: ELECTRONICS TECHNOLOGY	181.321	199.396	223.841						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.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Advanced Microsystems Technology Program	5.000	5.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Advanced Microsystems Technology program will explore a range of advanced microsystem concepts well beyond existing current technologies. The program focuses 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. These initiatives include advanced high-resolution lithography, high-speed avalanche devices with response out to 2 micrometers (um); integration of periodic elements III-V material with silicon; and novel cryogenic electronics. *FY 2008 Accomplishments:* - Demonstrated photoresist capable of multiple in-situ exposure with enhanced resolution. - Demonstrated sub-35 nanometer (nm) half-pitch interometric liquid exposure capability. *FY 2009 Plans:* - Prepare report analyzing prospects for beyond roadmap technologies. - Deliver 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. - Demonstrate focal planes using dense monolithic 3-D integration of silicon electronics and compound semiconductor detectors. - Demonstrate ultra low-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 (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	34.625	11.250	4.790	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
capabilities of microwave and millimeter-wave (MMW) monolithic integrated circuits (MMICs) and in turn, enable future RF sensor, communication, and multifunction military capabilities. 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 2008 Accomplishments:* - Demonstrated epitaxial processes that yield + three percent uniformity over 75 mm wide bandgap substrates. - Initiated thermal management study to determine best packaging approach for high power, high frequency microwave and millimeter wave transistors. - Demonstrated 100 mm silicon carbide (SiC) and wide bandgap alternate substrates with less than 40 micropipe/cm squared and resistivity 10^7 power ohms-cm. - Demonstrated epitaxial processes that yield + one percent uniformity over 100 mm wide bandgap substrates. - Identified fabrication processes for robust microwave and mm-wave devices. *FY 2009 Plans:* - Identify thermal management concepts to sustain more than 1 KW/cm squared power density in high-power devices. - Optimize 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. - Demonstrate fabrication processes for robust microwave and mm-wave devices with radio frequency yields greater than seventy percent. - Demonstrate thermal management concepts to sustain more than 1 KW/cm squared power density in high power device.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Develop and utilize physics-based models that accurately predict device performance. - Demonstrate reproducible wide bandgap semiconductors (WBGS) device and monolithic integrated circuits (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 microwave millimeter-wave (MMW) devices and MMICs. - Demonstrate superior thermal management and packaging strategies.				
High Power Wide Band Gap Semiconductor Electronics Technology (U) The High Power Wide Band Gap Semiconductor Electronics Technology developed components and electronic integration technologies for high power, high frequency microsystem applications based on wide bandgap semiconductors. *FY 2008 Accomplishments:* - Demonstrated megawatt Class silicon carbide (SiC) power devices. - Demonstrated high power density packaging for greater than 10 kV operations.	1.500	.000	.000	
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, and longer decoherence times will address the loss of information. Signal attenuation will be overcome by exploiting	1.966	3.350	3.230	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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 2008 Accomplishments:* - Investigated alternative designs, architectures and devices for quantum communication and demonstrated high-rate (1Gbit/sec) quantum-secure communication over a single link. *FY 2009 Plans:* - Investigate unresolved fundamental issues related to quantum information science. - Employ qubit architectures to demonstrate applications of interest to the DoD (e.g., quantum repeater, secure metropolitan-area network). - Demonstrate 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 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.				
Submillimeter Wave Imaging Focal Plane Array (FPA) Technology (SWIFT) (U) The Submillimeter Wave Imaging Focal Plane Array (FPA) Technology (SWIFT) program developed revolutionary component and integration technologies to enable exploitation of this spectral region. A specific objective was the development of a new class of sensors capable of low-power, video-rate, background and diffraction limited submillimeter imaging.	1.046	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Developed sensitive and large format receiver arrays, advanced integration, and backend signal processing techniques. - Developed and demonstrated a submillimeter focal plane imager.				
Technology for Frequency Agile Digitally Synthesized Transmitters (TFAST) (U) The Technology for Frequency Agile Digitally Synthesized Transmitters (TFAST) program (Ultra High-Speed Circuit Technology) developed super-scaled Indium Phosphide (InP) Heterojunction Bipolar Transistor (HBT) technology compatible with a ten-fold increase in transistor integration for complex mixed signal circuits. Phase I established the core transistor and circuit technology to enable the demonstration of critical small scale circuit building blocks suitable for complex mixed signal circuits operating at speeds three times that currently achievable and ten times lower power. Phase II extended the technology to the demonstration of complex (more than 20,000 transistors) mixed signal circuits with an emphasis on direct digital synthesizers for frequency agile transmitters. *FY 2008 Accomplishments:* - Developed full circuit capability using super-scaled InP HBTs in complex (more than 20,000 transistors) circuits. - Established device models and critical design rules. - Advanced the development of world's fastest InP HBT device technology.	7.391	.000	.000	
Feedback-Linearized Microwave Amplifiers (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. This program will leverage technologies from the TFAST program.	5.360	3.910	2.650	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Developed indium phosphide (InP) Heterojunction Bipolar Transistor (HBT)-based ultra-high linearity low-noise amplifier circuit architecture and developed low-noise InP High Electron Mobility Transistor (HEMT) devices. *FY 2009 Plans:* - Develop and enhance InP HBT-based RF operational amplifier and InP 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 phase-III low-noise amplifier module.				
Terahertz Electronics* *Formerly Terahertz Imaging Focal-Plane Technology (TIFT). (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.	5.260	11.000	11.980	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Demonstrated a compact THz source achieving at least 10 mW of average power and one percent wall plug efficiency, as required for active illumination and/or for local oscillators in heterodyne or homodyne detection schemes. *FY 2009 Plans:* - Develop devices and circuits for candidate applications with demonstration of operation at a frequency of at least 0.67 THz. - Demonstrate 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.				
Trusted, Uncompromised Semiconductor Technology (TrUST) (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 consists of a set of complementary technologies integrated together in order to develop a product that could be transitioned to the DoD. The TrUST program has moved to Program Element 0602303E, Project IT-03 in FY 09 and out as the program focuses on "trusted" hardware and software validation. *FY 2008 Accomplishments:* - Demonstrated automated Focus Ion Beam (FIB) delayering, Scanning Electron Microscope (SEM) imaging, and image processing to reconstruct the Integrated Circuit (IC) Gieber Data Standard (GDSII) from SEM images. - Developed automated algorithms for inspecting the Register Transfer List (RTL)-to-Netlist and Netlist-to-GDS components of the design flow for the protection of the IC design files.	19.281	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Created techniques to associate logic cell libraries with functional characteristics provided in 3rd Party Intellectual Property (IP) specifications in Application Specific Integrated Circuits (ASICs) and Field Programmable Gate Arrays (FPGAs) for the protection of 3rd Party IP blocks. - Developed techniques to ensure that the bit-stream accurately represents what was originally designed in the RTL description for protection of FPGA program files. - Developed Physically Unclonable Functions to authenticate FPGAs to protect FPGAs from substitutions.				
Carbon Electronics for RF Applications (CERA) (U) The 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 2008 Accomplishments:* - Demonstrated hybrid graphene-silicon complimentary metal-oxide semiconductor (CMOS) circuits for high performance and low power applications. *FY 2009 Plans:* - Develop synthesis process for wafer-scale graphene thin films. - Demonstrate feasibility of graphene channel based FETs. *FY 2010 Plans:* - Optimize synthesis process for wafer-scale graphene thin films. - Optimize RF-FETs based on graphene channels.	8.167	7.146	7.525	
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	1.589	18.040	12.519	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Developed methods for sub-circuit integration onto fully processed complimentary metal-oxide semiconductor (CMOS) wafers. - Developed scalable electro-magnetic (EM), thermal and mechanical models. - Estimated thermal and mechanical properties of integration materials, performed thermal and stress modeling to determine and improve the viability of the COSMOS thermal and mechanical design. *FY 2009 Plans:* - Fabricate wafers using the COSMOS process. - Evaluate alignment and bonding methods to achieve mechanical integrity of dissimilar materials, post-processing compatibility with CMOS, and the achievement of high fabrication yields. - Extend 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. - Demonstrate large (greater than 1 mm) devices. - Decrease 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.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Steep-subthreshold-slope Transistors for Electronics with Extremely-Low Power (STEEP)	3.424	5.306	9.080	

(U) The Steep-subthreshold-slope Transistors for Electronics with Extremely-low Power (STEEP) program goal is to develop revolutionary transistor technologies, which enable devices to be operated at voltages as low as 0.2 V without loss in performance (defined by available drive current). The approach is 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 will mainly focus 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 will also be developed in the program to enable novel ultra-low power circuit designs. At the end of the program, complex demonstration circuits will achieve significant power savings, both active and standby, of at least twenty-five times. The STEEP transistors will utilize 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 key technical challenges of the program will include (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 will start with the development of transistors with less than 30mV/dec of sub-threshold slope and then proceed to demonstrate the integration of these devices into logic circuits using an eight inch wafer technology. Finally, the STEEP program will focus on the yield improvement of a complex ultra-low power static random access memory (SRAM) circuit.

FY 2008 Accomplishments:
- Developed transistors with 30 mV/dec of subthreshold slope.

FY 2009 Plans:
- Develop associated device models of band-to-band tunneling transistors.
- Engineer transistor structures and begin fabrication of key device modules capable of meeting performance milestones of low power consumption and good performance.

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Further optimize the STEEP transistor performance and models. - Develop integrated fabrication processes capable of producing transistors and basic circuits. - Validate ultra-low power performance using a ring oscillator and a static random access memory (SRAM).				
High Frequency Integrated Vacuum Electronic (HiFIVE)* *Formerly titled Compact Vacuum Electronic Radio-Frequency Technology (COVERT). (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 (HPA) 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 2008 Accomplishments:* - Demonstrated a high aspect ratio beam with required power and transport efficiency. *FY 2009 Plans:* - Validate cold test interaction of structure design and high current density cathode. - Explore/identify 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.	5.693	9.090	8.430	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF)	4.577	4.042	4.000	

(U) The operation of frequency-hopping radios greatly interferes with co-located ultra-sensitive receivers. The situation will get worse as the “hoppers” proliferate, even interfering within the receive channels of one another. At present there is no solution to this problem, other than turning off the receivers when communicating. A general solution would be to use “brick-wall” front-end filters for the receivers, retuning at the rate of the hoppers, if such agile filters were available. High-temperature superconducting (HTS) filters have been used very successfully for negating strong transmissions at nearby frequencies, and are unique in their ability to totally reject out-of-band signals without attenuation of signals in the pass-band. However, they have been used only for rejection of fixed-frequency interference.

(U) The Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF) program will increase the tuning speed of 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. 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.

FY 2008 Accomplishments:
- Demonstrated one microsecond switching of high-temperature superconducting (HTS) filters, between three frequencies.
- Developed models of the HTS tunable filters.
- Achieved microsecond stepwise semiconductor switching between three stable states.

FY 2009 Plans:
- Continue development of low-loss semiconductor tuning elements for HTS filters, operating at cryogenic temperatures.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Complete development of low-loss semiconductor tuning elements for HTS filters, operating at cryogenic temperatures.				
Adaptive Focal Plane Arrays (AFPA) (U) The goal of the Adaptive Focal Plane Arrays (AFPA) program is 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 will also enable 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 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 2008 Accomplishments:* - Integrated detector array. - Demonstrated pixel-by-pixel electrical tunability in infrared. *FY 2009 Plans:* - Demonstrate AFPA prototype field using a large format array.	2.920	1.275	.000	
Chip-to-Chip Optical Interconnects (C2OI) (U) Continuing advances in integrated circuit technology are expected to push the clock rates of Complimentary Metal-Oxide Semiconductor (CMOS) chips into 10 gigahertz (GHz) range over the next five to seven 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	2.700	3.112	3.025	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Integrated optical transmitters/receivers and optical data paths with electronic packaging. *FY 2009 Plans:* - Develop a chip-scale opto-electronic transceiver circuit based on C2OI technology and demonstrate operation equivalent to 1 Terabit per second (Tbit/s) (consisting of twenty-four bidirectional channels each operating at 20 Gigabits/second (Gb/s)). - Develop 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. - Complete a Technology/Manufacturing Readiness Assessment for C2OI technology with respect to commercial supercomputing and military high-performance embedded computing environments.				
Photonic Analog Signal Processing Engines with Reconfigurability (PhASER) (U) The goal of the Photonic Analog Signal Processing Engines with Reconfigurability (PhASER) program is the creation of new Photonic Integrated Circuit (PIC) elements, and associated programmable filter array concepts that will enable high-throughput, low-power signal processors. The focus is 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 2008 Accomplishments:* - Defined and designed a novel analog photonic "Unit Cell" that was nominally comprised of a sub-array of waveguide-connected programmable active elements.	3.496	3.980	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Demonstrated that the Unit Cell was externally linkable with integrated waveguides, and could function as a building block in programmable PIC arrays for generalized high-order finite impulse response/infinite impulse response (FIR/IIR) filters. *FY 2009 Plans:* - Demonstrate an experimental Unit Cell concept. - Determine how the Unit Cell, when arrayed within a high-density PIC, will perform. - Develop a filter synthesis tool to demonstrate how Unit Cells will enable generalized high-order filters. - Determine how unit cells will be programmed and tested at the chip-level to ensure high yield.				
Linear Photonic RF Front End Technology (PHOR-FRONT) (U) The goal of the Linear Photonic RF Front End Technology (PHOR-FRONT) program is 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. *FY 2008 Accomplishments:* - Developed narrow line-width, 1,550 nanometer (nm) lasers with improved efficiency, relative intensity noise (RIN), and stability. *FY 2009 Plans:* - Develop compact linear photonic receivers with improved sensitivity and dynamic range.	7.238	2.875	.000	
Optical Arbitrary Waveform Generation (OAWG) (U) The ultimate vision for the Optical Arbitrary Waveform Generator (OAWG) program is 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	.964	4.284	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
numerous high-level applications including sub-diffraction-limited imaging and ultra-wide band optical communications. *FY 2008 Accomplishments:* - Continued to develop 10 Gigahertz (GHz) octave-spanning carrier-envelope stabilized laser with integrated molecular frequency standard. - Continued to design and build miniature 10 Gigabyte/second multi-channel, parallel bit-error rate testbed for integrated system testing. *FY 2009 Plans:* - Demonstrate 1,000 GHz positive linear chirp with less than five percent least-squared deviation from mathematical ideal waveform. - Demonstrate production of single-cycle, 3 GHz square wave with fidelity of less than one percent least-squared deviation from mathematical ideal waveform. - Investigate insertion of OAWG technology into high performance radar and laser radar systems.				
Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) (U) The Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) program will develop a brain inspired electronic “chip” that mimics the function, capacity, size, and power consumption of a biological cortex. If successful, the program will provide the foundations for functional machines to supplement humans in many of the most demanding situations faced by warfighters today. In particular, the objective of the program is to process video images for information abstraction (e.g. annotation) and task initiation. The two main technical challenges to achieving this vision are developing an artificial electronic synapse and developing a neural algorithm-architecture that exploits these synapses. *FY 2008 Accomplishments:* - Initiated development of video image processing for information abstraction.	4.652	21.486	22.361	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop a nanometer scale electronic synapse exhibiting the critical communication, processing and learning functions of biological synapses. - Develop 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. - 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.				
Ultrabeam (U) The goal of the Ultrabeam program is to demonstrate the world's first gamma-ray laser using laboratory equipment. The demonstration of an X-ray laser with photon energies of 4-5 thousand electron volts (KeV) (Xenon laser at 2-3 Angstrom wavelengths) in the first phase of the Ultrabeam program opens the possibility of creating gamma-ray lasers with photon energies equivalent to 100 KeV – 1 million electron volts (MeV). 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 2008 Accomplishments:* - Identified candidate gamma ray gain systems.	2.188	3.419	2.647	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Obtained evidence for X-ray beam collapse in solid targets. - Analyzed new laboratory equipment including a new highly reliable ten times brighter Excimer Pre-Amp Laser with high beam to enable more efficient coupling of greater pump powers into the X-ray laser amplification channel for scaling of the X-ray laser output. *FY 2009 Plans:* - Demonstrate excitation of inner shell and nuclear levels in candidate gamma ray gain media. - Demonstrate modeled gain of greater than 50 cm^-1 in high atomic-number (Z greater than 70) candidates. - Estimate X-ray source scaling limits and source requirements for candidate gamma ray gain systems. - Demonstrate 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.				
Photonic Bandwidth Compression for Instantaneous Wideband A/D Conversion (U) The objective of the Photonic Bandwidth Compression for Instantaneous Wideband A/D Conversion (PHOBIAC) program is to develop revolutionary technologies to enable Analog to Digital Converters (ADCs) with high-resolution and large instantaneous bandwidth while maintaining power consumption that is commensurate with user community requirements. It is expected that such ADCs would have a dramatic impact on signals intelligence capabilities such as direct down conversion of ultra high frequency through X-band radio frequency (RF) signals. Furthermore, ADCs enabled by this program alleviate the current ADC bottleneck in high capacity digital RF communications links by enabling more spectrally efficient wideband waveforms. This program aims to develop a bandwidth-compressing photonic front end that provides a force multiplier for any available back-end electronic ADCs. *FY 2008 Accomplishments:* - Demonstrated transient ADC with 6.5 estimated number of bits (ENOB) signal-to-noise ratio over a 10 gigahertz bandwidth. - Developed a low-power ADC with high-dynamic range for an improved ENOB.	2.312	4.057	3.525	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop and enhance a low-power ADC with high-dynamic range for further improvement in the ENOB. *FY 2010 Plans:* - Develop a low-power ADC with enhanced ENOB and spurious-free dynamic range. - Develop and fabricate optical elements with high dispersion and low loss. - Investigate methods to improve noise performance of mode-locked laser systems while maintaining or improving output power and wall-plug efficiency.				
Optical Antenna Based on Nanowires (U) This program evaluated nano-meter scale structures that could act as optical antenna arrays that would respond coherently to electromagnetic fields at optical wavelengths. A system based on this technology would potentially be smaller, lighter in weight, and able to move from the sub-optimal method of intensity-only measurements into the information-rich domain of complex imaging. *FY 2008 Accomplishments:* - Completed a study on small element count 2-Dimensional array to identify performance and scaling relationships.	1.000	.000	.000	
Chip Scale Atomic Clock (CSAC) (U) The Chip Scale Atomic Clock (CSAC) will demonstrate 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. *FY 2008 Accomplishments:* - Demonstrated subcomponent fabrication including atomic chamber, excitation and detection function.	4.519	3.471	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Demonstrate design and fabrication innovation for atomic-confinement cell and for gigahertz (GHz) resonators suitable for phase locking or direct coupling with atomic confinement cell.				
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 2008 Accomplishments:* - Demonstrated advances in power output and particle capture with high conversion efficiencies, while operating within safety considerations and limitations. *FY 2009 Plans:* - Demonstrate advanced dielectrics with high stability suitable for solid-state capture devices. *FY 2010 Plans:* - Demonstrate long lasting power generation in a militarily useful form factor.	1.946	1.000	1.000	
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	7.664	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
applications, such as unattended sensors, perimeter defense, detection of weapons of mass destruction; and environmental protection. *FY 2008 Accomplishments:* - Demonstrated radiation hardened Boron Carbide (BC) junctions with greater than ten percent efficiency. - Demonstrated thermophotovoltaic conversion system. - Demonstrated thermo electric conversion system.				
Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM) (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. The NTOMM program will leverage recent and ongoing developments in nano-material synthesis and assembly, which have demonstrated the potential for over fifty percent precursor stream usage in the fabrication of II-VI and III-V materials. An additional focus of the NTOMM program is the development of technologies to support the fabrication of low-cost high pixel density power efficient direct emission microdisplays. Current microdisplay systems use light modulation systems (Liquid Crystal Displays, Digital Micromirror Devices) and consequently only transmit a small fraction of the light from the illumination source thus limiting efficiency and use. *FY 2008 Accomplishments:* - Began development of cost effective synthesis methods for Group II-VI and III-V materials. - Developed higher temperature processing methods and hardware to provide better quality crystalline GaN.	3.750	3.000	2.500	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**	
FY 2009 Plans: - Develop and demonstrate techniques for layer doping of heterostructure materials. - Demonstrate fabrication technologies that support the fabrication of affordable emissive microdisplays. - Extend novel fabrication techniques to demonstrate initial device concepts. - Grow monodrystalline p-type GaN material with biased target based deposition based manufacturing process. - Demonstrate lift-off and substrate recycling. - Identify process optimization paths for improved material characteristics and expanded potential suite of low-cost devices that can be fabricated. *FY 2010 Plans:* - Demonstrate scalability of novel manufacturing techniques.					
Cognitively Augmented Design for Quantum Technology (CAD-QT) (U) The Cognitively Augmented Design for Quantum Technology (CAD-QT) program will enable rapid design, prototyping, and high-yield manufacture of next generation electronic, photonic, and magnetic devices that fully exploit quantum effects. One foundation of modern semiconductor electronics is that numbers of electronic carriers (electrons and holes) is large and this allows designers to rely on simple, semi-classical statistical models. As device dimensions become progressively smaller, quantum effects can no longer be treated as semi-classical statistical events and a complete and detailed quantum representation must be utilized. However, from the perspective of the human designer, quantum mechanics without statistical models is highly counterintuitive. The CAD-QT program will apply advances in robust optimization, dimensionality reduction, and modeling build tools for enhancing designer intuition for complex quantum systems optimized for high function and high yield under manufacturing variations. *FY 2008 Accomplishments:* - Extended CAD-QT quantum electronic device modeling and optimization tool for 3-Dimensional device structure.	1.339	5.000	5.500		

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Develop optimization tools with automated search algorithms for heterojunction bipolar transistors (HBTs) operating in the 500 GHz to 1 THz region. *FY 2010 Plans:* - Optimize design and develop maskset design for ultra-high frequency HBT device.				
Ultra-Low Power Subthreshold Electronics (UPSE) (U) The Ultra-Low Power Subthreshold Electronics (UPSE) program will achieve a greater than ten times reduction in energy consumption for integrated circuits by developing technology that allows for circuit operation at the physical limits of power supply voltages. The objective of the UPSE program is to develop a circuit technology that will allow operation of devices in the subthreshold regime (less than or equal to 0.3 V) in contrast to the typical super-threshold regime (equivalent to 1.0 V). Particular emphasis is placed on the use of standard commercial complementary metal-oxide-semiconductor (CMOS) technology avoiding the need for specialized custom device fabrication. Application-specific parallelism will be leveraged for maintaining adequate performance in the sub-threshold regime while still consuming minimal power. A demonstration sensor or communication integrated circuit (IC) of significant military interest showing compelling low power performance and new mission capabilities will be built. *FY 2009 Plans:* - Develop standard cell digital design library that is capable of operating in subthreshold, near threshold and superthreshold voltage regimes. - Demonstrate highly efficient on-chip dc-dc converter for voltages less than 1 V. - Determine appropriate “granularity” of voltage/threshold domains in a digital IC for optimum low-power performance. *FY 2010 Plans:* - Design digital IC demos of DoD interest using low power libraries. - Fabricate several demo designs using advanced commercial foundry CMOS process. - Develop on-chip adaptive bias/threshold control scheme with fine-grained voltage domains.	.000	6.361	6.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Short-range Wide-field-of-regard Extremely-agile Electronically-steered Photonic Emitter and Receiver (SWEEPER)	.000	4.000	7.500	
Analog-to-Information (A-to-I)	2.869	5.970	8.910	

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 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 Plans:
- Create a chip-scale optical beam forming and scanning technology.
- Combine architecture and technology to address integrated control of phased optical signals.

FY 2010 Plans:
- Demonstrate chip scale beam-forming capability in laboratory.
- Evaluate transmit and receive photonic phased array technologies.

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 and the future. Additionally, by extracting signals of interest during the measurement phase, A-to-I based approaches

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Organized industry and academic teams to develop A-to-I receiver designs that address challenging DoD RF application scenarios. - Formulated, finalized, and established detailed simulation studies. *FY 2009 Plans:* - Systematically exploit 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.				
Computational Imaging (CI) (U) The Computational Imaging (CI) 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. *FY 2009 Plans:* - Begin the prototype development of a practical 3-Dimensional (3-D) spatial imager that captures intensity, frequency, and phase information of naturally illuminated scenery.	.000	3.000	7.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Demonstrate prototype 3-D spatial imager with associated spatial processing algorithms.				
Electric Field Detector (E-FED)* *Formerly titled Non-contact EEG Technologies (NET). (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 Plans:* - Develop electric field sensors that utilize the modification of optical fields due to the presence of an electric field. *FY 2010 Plans:* - Explore techniques to control the effect of noise sources on the sensor function. - 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.	.000	3.000	6.000	
Integrated Photonic Delays (iPhoD)* *Formerly titled Ultra Low Loss Photonic Integrated Circuits and Processors. (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	.000	3.000	6.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 2 - Applied Research	PE 0602716E ELECTRONICS TECHNOLOGY	ELT-01

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
the handling and manipulation of photons with throughput efficiency and precision approaching that of electrons within electronic integrated circuits. *FY 2009 Plans:* - Demonstrate 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.				
Processing Algorithms with Co-design of Electronics (PACE) (U) The Processing Algorithms with Co-design of electronics (PACE) program enables the co-design of the next generation of embedded signal processing algorithms and architectures capable of processing large sparse matrix data structures associated with graph structured signal processing algorithms. Graph algorithms are the key to post-detection signal processing, helping us “connect the dots” in a huge variety of emerging challenges ranging from network analysis, change detection in massive sensor data transactions, and forensic and predictive analyses of activities from video data over wide areas and extended times. The goal of the PACE program is to provide the DoD with an architecture and algorithm co-design capability for performing Graph-structured signal processing. Solutions available today that might meet these mission requirements are limited by prohibitively long and costly manual design times. The PACE program will provide signal processing capabilities not possible today while achieving dramatically reduced design time and cost. *FY 2009 Plans:* - Develop preliminary computational architectures that are optimized for processing of complex graph algorithms. - Begin implementation of microprocessor emulators.	.000	3.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Demonstrate a better than ten time improvement of emulated processor over similar graph algorithms implemented on conventional Von Neumann computer platforms. - Develop co-design capability for hardware and software data analysis.				
Visible InGan Injection Lasers (VIGIL) (U) The objective of the Visible InGan Injection Lasers (VIGIL) program is to demonstrate injection lasers emitting in the green wavelength. The specific program goal is 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 2008 Accomplishments:* - Demonstrated watt-level Indium Gallium Nitride (InGaN)-based injection lasers emitting in the visible wavelengths of 460-520 nanometers (nm). - Demonstrated optically pumped stimulated emission at 512 nm wavelength on a semi-polar semiconductor substrate. *FY 2009 Plans:* - Grow InGaN quantum wells with low defect densities (less than 10,000 defects per square cm) on both polar and non-polar Gallium Nitride substrates. *FY 2010 Plans:* - Demonstrate room temperature pulsed laser diodes at 500 nm with 200 milliwatts output laser power. - Demonstrate operation of a laser diode with differential efficiency of twenty percent. - Demonstrate stable operation of a VIGIL laser for 500 hours.	6.588	5.832	5.848	
Quantum Sensors	.000	9.000	10.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) The Quantum Sensors program is developing approaches to exploit non-classical effects called entanglement to improve the resolution and range of military sensors. The objective of the program is to enhance sensitivity, resolution, and effectiveness of electromagnetic sensors beyond what is classically possible. The theoretical proof stage of the Quantum Sensors program was funded in FY 2007 and 2008 under PE 0601101E, Project MS-01. In that stage, sensors that propagate entangled light out to and back from a target (Type I) 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 entangled light only in the receiver (Type II) 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 that retains entangled light in the receiver and transmits it to the target (Type III) was discovered and promises substantial enhancements over detection and imaging of targets in the presence of high levels of noise and loss. *FY 2009 Plans:* - Begin engineering of sensor systems based on entangled light. - Demonstrate and quantify compensation of soft aperture loss by squeezed vacuum injection in homodyne laser radar in a range environment. - Demonstrate noiseless amplification for sensors with low quantum efficiency. - Design a quantum illumination system prototype. *FY 2010 Plans:* - Build and field test prototype entangled laser radar. - Demonstrate detection using quantum illumination in laboratory and range environments.				
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 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	1.145	2.142	3.877	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated enhanced non-linearities of silica fibers and silicon waveguides. - Demonstrated two-pump method for generation of 160 Gigabit per second (Gb/s) Data Streams. - Demonstrated 403 nanosecond (ns) tunable optical delay elements. *FY 2009 Plans:* - Demonstrate serializer component with data rate of 320 Gb/s. - Demonstrate deserializer component with granularity of 40 Gb/s. - Demonstrate 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)* *Formerly titled Miniature, Room Temperature, Ultra-sensitive Magnetic Sensor (MRUMS). (U) The Spin Torque Transfer-Random Access Memory (STT-RAM) program (reclassified from PE 0603739E, Project MT-15) 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	9.310	2.818	8.167	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. *FY 2008 Accomplishments:* - Developed magnetic materials that allow for fast, low power switching in the Spin Torque Transfer (STT) architecture. *FY 2009 Plans:* - Develop fabrication techniques and device architectures that exploit the 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.				
Design Tools for 3-Dimensional Electronic Circuit Integration (U) The Design Tools for 3-Dimensional Electronic Circuit Integration program developed a new generation of Computer Aided Design (CAD) tools to enable the design of integrated 3-Dimensional (3-D) electronic circuits. The program focused on methodologies to analyze and assess coupled electrical and thermal performance of electronic circuits and tools for the coupled optimization of parameters such as integration density, cross talk, interconnect latency and thermal management. The goals of this initiative were to develop a robust 3-D circuit technology through the development of advanced process capabilities and the design tools needed to fully exploit a true 3-D technology for producing high performance circuits. The deliverables from this program will have a significant impact on the design of mixed signal (digital/analog/radio frequency) systems and Systems-on-a-Chip for high performance sensing, communications, and processing systems for future military requirements. *FY 2008 Accomplishments:* - Completed 3-D process technology development.	7.442	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Developed several compelling applications to map into the 3-D technologies. - Completed fabrication of 3-D demo design chips.				
Self-HEALing mixed-signal Integrated Circuits (HEALICs)	.000	11.500	13.590	
(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 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 Plans:* - Develop self-healing control for individual sub-blocks within a larger mixed-signal core. - Integrate sub-blocks into larger mixed-signal cores (anticipated transistor counts in the 1k-10k range). - Develop 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.				
COmpact Power Processing Electronics Research (COPPER)	.000	.000	7.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 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 2010 Plans:* - Complete design and initial fabrication of critical sub-circuits and perform measurements in laboratory. - Complete theoretical design and analyses for understanding of the high-frequency trade-off space of relevant circuit designs and topologies.				
Highly Linear Ultra-low Power RF-FETs using CNTs (ULP-LINFET) (U) The objective of the Highly Linear Ultra-low Power RF-FETs using CNTs (ULP-LINFET) program is to develop radio frequency (RF) field effect transistors (FET) using a layer of 1-Dimensional (1-D) aligned carbon nanotubes (CNTs) as the conduction channel to achieve high linearity and ultra-low power for defense sensor systems. CNTs, due to their one-dimensional physics and high current carrying capacity, offer the unique opportunity to achieve highly-linear, high-frequency, and ultra-low power in FET devices. Linearity of RF devices is extremely important in signal rich environments such as noisy battlefields with extensive jamming. Highly linear low noise amplifiers are critical for applications such as: RF front-end processing, broad-band digital communication, radar, synthetic aperture radar (SAR), electronic and signal intelligence (ELINT, SIGINT), electronic sensing (ESM), electronic warfare (EW) and other sensor systems employed in surveillance and reconnaissance C4ISR systems. *FY 2010 Plans:* - Develop techniques for fabricating large/dense 1-D arrays of parallel aligned CNTs.	.000	.000	5.187	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop method for the elimination of metallic CNTs without disruption of the remaining semiconducting CNTs by selective laser ablation or electro-plating. - Demonstrate ultra-low power low-noise amplifier while maintaining high linearity. - Demonstrate RF performance with maximum frequency of greater than 50 Gigahertz (GHz).				
Millimeter-wave All-Silicon Transmitters (MASTR) (U) The goal of the Millimeter-wave All-Silicon Transmitter (MASTR) 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 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.	.000	.000	4.000	
Transmit and Receive Optimized Photonics (TROPHY) (U) The objective of the Transmit and Receive Optimized Photonics (TROPHY) program is to develop ultra-wideband (0.1 to 20 Gigahertz (GHz)) photonic components (Photodetectors & Modulators) with significantly enhanced efficiency in comparison to conventional electronics for applications in antenna Transmit/Receive modules. It is expected that such components would have a significant impact on wideband, multi-functional, multi-beam, Active Electronically Steerable Array (AESA) antennas.	.000	.000	5.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Furthermore TROPHY components will obviate several thousands of co-axial cables per array replacing these with a much lighter and significantly broader band optical fiber. By developing modulators and detectors independently optimized for transmit and receive applications, TROPHY will deliver application specific, best in class components. *FY 2010 Plans:* - Enhance third-order intercept point (OIP3) of the Transmit link to +65 decibels relative to a milliwatt of power (dBm). - Enhance gain of the Receive link to 35 dB.				
Nitride Electronic NeXt-Generation Technology (NEXT) (U) The NEXT program will develop innovations in the area of advanced nitride electronics. Research will focus on innovative approaches to enable revolutionary advances in nitride electronic devices and integrated circuits resulting in the ability to operate at very high frequencies while maintaining extremely favorable voltage breakdown characteristics. *FY 2010 Plans:* - Develop self-aligned structure with short gate length, novel barrier layers and reduced parasitics. - Develop transistor models.	.000	.000	4.500	
3-D Technology for Advance Sensor Systems (U) The 3-D Technology for Advance Sensor Systems effort exploited 3-Dimensional (3-D) technology for applications in Advance Sensor Systems. *FY 2008 Accomplishments:* - Applied 3-D technology to device implementation. *FY 2009 Plans:* - Continue 3-D device development.	2.400	1.440	.000	
Indium Based Nitride Technology Development	.000	3.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Initiate Indium Nitride development.				
Secure Media and ID Card Development *FY 2009 Plans:* - Initiate ID card development.	.000	.240	.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, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	55.256	87.619	338.360						Continuing	Continuing
AIR-01: ADVANCED AEROSPACE SYSTEMS	55.256	87.619	338.360						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 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	71.925	107.857	324.607	
Current BES/President's Budget	55.256	87.619	338.360	
Total Adjustments	-16.669	-20.238	13.753	
Congressional Program Reductions	.000	-20.238		
Congressional Rescissions	-18.500	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	3.800	.000		
SBIR/STTR Transfer	-1.969	.000		
TotalOtherAdjustments			13.753	

Change Summary Explanation

FY 2008
Decrease reflects Section 8042 rescission, a below threshold reprogramming action, and the SBIR/STTR transfer.

FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and unexecutable growth.

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FY 2010
Increases reflect planned funding for technical milestones of major programs such as Rapid Eye, Vulture, ISIS, Vulcan and the Long Range Anti Ship Missile.

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
AIR-01: ADVANCED AEROSPACE SYSTEMS	55.256	87.619	338.360						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. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Heliplane	15.400	8.000	4.000	
(U) The Heliplane program is evaluating the 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. The Heliplane design will be tailored to a Combat Search and Rescue (CSAR) mission with a 400 mph cruise speed, a 1,000 lb payload, and an unrefueled range of 1,000 miles. The Heliplane program will conduct a combination of analysis and experiments to develop and demonstrate key enabling technologies. Once key enabling technologies have been demonstrated, a preliminary design of the Heliplane system will be completed, a subscale test of the rotor system will be conducted to demonstrate that the rotor is stable in high-speed flight, and a combination of analysis and experiments will be conducted to verify that the tip-jet meets noise requirements. *FY 2008 Accomplishments:* - Initiated the preliminary design of an alternate rotor configuration with a >10 dB reduction in noise from the tip-jet. *FY 2009 Plans:* - Complete preliminary design of an alternate rotor configuration with a >10 dB reduction in noise from the tip-jet. - Complete the design of the rotor and controls.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiate the design of a scale model of the Heliplane and of a tip-jet nozzle. *FY 2010 Plans:* - Complete the design and fabrication of a scale model of the Heliplane and a tip-jet nozzle. - Demonstrate the capability for stable operation of the Heliplane at high speed in a wind tunnel. - Demonstrate a >10 dB reduction in noise from the tip-jet.				
Oblique Flying Wing (OFW) (U) The goal of the Oblique Flying Wing (OFW) program was to expand the design space for future aircraft concepts, particularly for those missions that demand both supersonic speed and long endurance. The potential for a unique combination of excellent high speed and low speed performance would enable rapid deployment and long loiter time, for example, in surveillance or combat air patrol (CAP) roles. The OFW program considered technologies such as advanced controls to develop and fly a small-scale supersonic technology demonstrator X-Plane, and identified key design requirements for an objective system. *FY 2008 Accomplishments:* - Conducted stability and control analysis to evaluate predicted trim and handling characteristics of OFW design. - Completed development of a dynamic flight simulation tool, which couples modeling of rigid-body aerodynamics and aeroelasticity effects for control system development and evaluation. - Completed preliminary design review of OFW X-Plane. - Evaluated feasibility of OFW concept and confirmed that the concept is feasible, with no known technical obstacles preventing stable flight through sweep changes for a supersonic vehicle.	1.650	.000	.000	
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,	3.706	2.649	2.500	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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; methods to intercept and defeat enemy UAVs; autonomous refueling for air vehicles; 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; payload and cargo handling systems; and the ability of fixed wing UAVs to perform perch-and-stare missions. *FY 2008 Accomplishments:* - Performed studies on critical strike munitions, hypersonics, and novel propulsion systems. - Investigated the use of novel propulsion systems allowing small fixed wing UAVs to perform perch-and-stare missions. - Evaluated advanced high-performance rotor system concepts for tiltrotor aircraft. *FY 2009 Plans:* - Perform studies of candidate technologies and develop system concepts. - Conduct modeling and simulation of system architectures and scenarios. - Develop, analyze, and assess 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.				
A160 (U) The A160 program will exploit a hingeless, rigid rotor concept operating at the optimum rotational speed to produce a vertical take-off and landing (VTOL) unmanned aerial vehicle (UAV) with low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2,000 nautical miles) and/or endurance (>20 hours). The focus of the remaining program is on reliability and airworthiness	5.000	2.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
improvements, sensor carriage Electro-Optics/Infrared (EO/IR), stub wings – weapons carriage capability and flight envelope expansion. To date, proof of concept flight tests have demonstrated platform performance goals, including an endurance of over eighteen hours unrefueled, hover outside ground effect at an altitude of 15,000, high speed flight at 145 knots and carriage of a logistic payload of 1000 lb over a distance of 962 kilometers. Improved airworthiness, reliability, and autonomous capabilities of the vehicle have also been demonstrated. The A160 concept has the potential to meet a range of surveillance and targeting, communications and data relay, crew recovery, resupply of forces in the field, and special operations missions in support of Army, Navy, Marine Corps, and other agency needs. The program also provides a platform for integration and testing of emerging sensor technologies for the detection of persons moving below the forest canopy or otherwise obscured. These technologies can further advance current range and endurance. The A160 program will transition to the Army and Special Operations Command (SOCOM). *FY 2008 Accomplishments:* - Achieved flight endurance, hover outside ground effect, payload and high speed performance goals. *FY 2009 Plans:* - Complete flight envelope expansion, reliability and airworthiness improvements and sensor and weapon facility enablement. - Transition program to the Army and SOCOM.				
Rapid Eye (U) The goal of the Rapid Eye program is to develop a high altitude, long endurance unmanned aircraft that can be rocket-deployed from the continental United States world-wide within 1-2 hours to perform intelligence, surveillance, reconnaissance (ISR), and communication missions. The enabling technologies are inflatable/folding structures, stable and dense energy storage, and low-oxygen propulsion. Rapid Eye will provide decision makers rapid-reaction ISR and persistent communication capability for emerging situations. The anticipated transition partner is the U.S. Air Force.	16.200	38.100	64.690	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Performed multi-team conceptual design study of system trades to include launch locations and systems; aircraft altitude, survivability and endurance; and technology possibilities, effectiveness, and affordability through modeling and simulation. *FY 2009 Plans:* - Develop Rapid Eye risk management, technology development and system maturation plan. - Complete system conceptual design and system requirements review. *FY 2010 Plans:* - Perform subsystem technology development and laboratory subscale tests. This will include engine cycle demonstration in an altitude chamber; laboratory packing, deployment, and load testing of the wing concept and atmospheric decelerator; wind tunnel deployment and performance testing of the wing concept and atmospheric decelerator; and material heat flux and temperature testing of atmospheric decelerator.				
Vulture (U) The objective of the Vulture program is to develop an aircraft capable of remaining on-station uninterrupted for over five years to perform intelligence, surveillance, and reconnaissance (ISR), and communication missions over an area of interest. The technology challenges include development of energy management and reliability technologies capable of allowing the aircraft to operate continuously for five years. Vulture, in effect, will be a re-taskable, persistent pseudo-satellite capability, in an aircraft package. The Vulture program will conduct a subscale three-month flight demonstration to prove out critical technologies. Subsequently, the program will conclude with a year-long flight demonstration with a fully functional payload. The anticipated transition partner is the Air Force. *FY 2008 Accomplishments:* - Performed multi-team conceptual design study of system trades to include aircraft altitude, survivability, payloads, and missions; effectiveness; and affordability through modeling and simulation. - Developed risk mitigation and technology maturation plan.	8.900	22.870	52.450	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Began technology development in the area of aeroelastic modeling tools. *FY 2009 Plans:* - Downselect a configuration for demonstration in Phase II and III. - Maturation of energy management and reliability technologies. - Conduct initial risk reduction sub-subscale tests. - Demonstration of component performance and reliability including energy storage, propulsion, and flight management/control systems. - Initiate detailed design of the sub-scale and full-scale demonstrator aircraft. *FY 2010 Plans:* - Continue subsystem and component risk reduction testing for reliability and performance. - Perform subscale flight demonstration vehicle critical design review and initiate long lead fabrication. - Downselect a system for Phase III demonstration.				
Multi-Modal Missile (U) The Multi-Modal Missile program will explore the development of an integrated, networked man-portable weapon system capable of performing surface-to-surface, and surface-to-air missions with an emphasis on extreme precision. The program will focus on delivering precision targeting accuracy in both direct and indirect fire modes against multiple targets, and beyond line-of-sight functionality including; armored and soft ground vehicles, bunkers, personnel, helicopters and unmanned aerial vehicles (UAVs). The Multi-Modal Missile will be compatible with existing Javelin and TOW launch infrastructures. The objective Multi-Modal Missile capability will integrate a variety of existing weapons-systems functions and provide both mounted and dismounted soldiers with an affordable compact system. Critical characteristics of this weapon system concept include light weight, simple operation, and affordability. Technologies under consideration will include advanced imaging seekers, precision terminal guidance, propulsion, power storage, vertical launch with lock-on-after-launch capability, and novel warhead concepts to support a wide range of engagement geometries with desired lethality effects against a range of targets. Anticipated service users include the Army, Marines and Special Forces.	.000	6.500	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop, analyze and assess initial Multi-Modal Missile technical approaches.				
Stealthy, Persistent, Perch and Stare (SP2S) (U) The goal of the Stealthy, Persistent, Perch and Stare (SP2S) program is to develop the technology to enable an entirely new generation of perch-and-stare micro air vehicles, based on the Wasp platform, capable of: 1) vertical launch, 2) forward flight to a target, 3) transition from forward flight to hover, 4) 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) at mission end SP2S would re-launch from the perch and fly home. During perch-and-stare, SP2S would perform surveillance and transmit live video/still images beyond line-of-sight back to the home base, utilizing other low altitude unmanned aerial vehicles (UAVs) as relay links, as required. Anticipated service users include the Army, Marines and Special Forces. *FY 2008 Accomplishments:* - Analyzed 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. - Conducted enabling technology and sub-system feasibility experiments. *FY 2009 Plans:* - Mature and integrate advanced technologies and subsystems. - Fabricate perch-and-stare field test systems. - Conduct field/operational tests. *FY 2010 Plans:* - Develop auto-pilot for semi autonomous landing. - Identify energy harvesting technologies and methodologies that enable aircraft to remain operational over a 24-hour period. - Develop attachment/perching technologies that are applicable to a wide variety of terrains. - Develop schemes for exploitation of digital communications.	2.400	2.500	2.700	
Triple Target Terminator (T3)	.000	.000	7.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Triple Target Terminator (T3) program will develop a high speed, long-range missile that can engage counter air, counter cruise missile and Destruction of Enemy Air Defenses (DEAD) 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. *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.				
Integrated Sensor is Structure (ISIS) (U) The Integrated Sensor is Structure (ISIS) program, previously funded under PE 0603287E, Project SPC-01, 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. The ISIS technology is planned for transition to the Air Force. *FY 2010 Plans:* - Conduct critical design review of demonstration system. - Conduct radar system operational modeling and simulation.	.000	.000	63.400	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop and demonstrate flight dynamic controls in a lab environment. - Demonstrate large-scale manufacturing of prototypes and initial integration.				
Vulcan (U) The goal of the Vulcan demonstration program, previously funded from PE 0602702E, Project TT-07 (HiSTED Program), is to design, build and ground test an engine capable of accelerating a full scale hypersonic vehicle from rest to Mach 4+. Constant Volume Combustion (CVC) engines have 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 propulsion system capability. CVC engines, when combined with turbine engines, offer the ability to design a new class of Mach 4+ air breathing engines. The Vulcan engine will consist of a CVC engine, a full-scale turbine engine, an inlet and a nozzle. CVC engine architectures could include Pulsed Detonation Engines (PDE's), Continuous Detonation Engines (CDE's) or other unsteady CVC engine architectures. The CVC engine would operate from below the upper Mach limit of the turbine engine to Mach 4+. The turbine engine will be a current production engine capable of operating above Mach 2. Key objectives of the program are to integrate the turbine engine into the Vulcan engine with minimal modification to the turbine engine; to operate the turbine engine from rest to its upper Mach limit; and to cocoon the turbine engine when it is not in use. The Vulcan engine will enable full-scale hypersonic cruise vehicles for Intelligence, Surveillance and Reconnaissance (ISR), strike or other critical national missions. *FY 2010 Plans:* - Complete designs and simulations of critical components. - Conduct risk reduction demonstrations of the combustor rig, fuel system, material rig, valve rig, initiator rig, seal rig, inlet rig, nozzle rig, and thermal management system rig components. - Complete CVC engine preliminary design review. - Initiate detailed design of subsystems.	.000	.000	53.730	
Long Range Anti-Ship Missile Demonstration (LRASM) (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	.000	.000	54.950	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. The anticipated transition partner will be the U.S. Navy. *FY 2010 Plans:* - Continue risk reduction testing of critical components, including over-water seeker test, 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.				
Disc-Rotor Compound Helicopter (U) The goal of the Disc-Rotor 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 airplane flight would be achieved by fully retracting the blades within the disc. An aircraft capable of long range high speed (300-400 kts)	.000	5.000	7.940	

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
and vertical take-off and landing (VTOL)/hover will provide mobility and responsiveness for troop and cargo insertion, satisfy an ongoing military interest for higher speed VTOL and hover capable vehicles, be survivable and bridge the gap in helicopter escort and insertion missions. The enabling technologies are disc-rotor configuration, variable thrust ducted prop-fans, the extension of the telescoping blades and seamless reversible transition between hover and wing borne flight. Specific objectives of the Disc-Rotor 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 design and flight testing a demonstrator. In FY 2008, this program was funded from PE 0602702E, Project TT-07. The anticipated transition partner is the Air Force. *FY 2009 Plans:* - Complete small scale rotor design, and initiate fabrication. - Conduct analysis and refinement of the vehicle conceptual approach and configurations. - Perform computational fluid dynamics analyses and predictions. *FY 2010 Plans:* - Develop, and fabricate sixteen foot rotor model. - Conduct wind tunnel testing of air vehicle and rotor model.				
Mode Transition (MoTr) Demonstration (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 Falcon combined-cycle engine technology 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.	.000	.000	25.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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.				
Buoyancy Assisted Lift Air Vehicle *FY 2008 Accomplishments:* - Investigated a buoyancy assisted lift air vehicle.	2.000	.000	.000	

C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
ISIS/Air Force	.000	.000	75.000						Continuing	Continuing
LRASM/Navy	.000	.000	21.700						Continuing	Continuing

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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	146.494	226.394	200.612						Continuing	Continuing
SPC-01: SPACE PROGRAMS AND TECHNOLOGY	146.494	226.394	200.612						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.

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	216.419	287.009	211.510	
Current BES/President's Budget	146.494	226.394	200.612	
Total Adjustments	-69.925	-60.615	-10.898	
Congressional Program Reductions	.000	-60.615		
Congressional Rescissions	-64.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	.000	.000		
SBIR/STTR Transfer	-5.925	.000		
TotalOtherAdjustments			-10.898	

Change Summary Explanation

FY 2008
Decrease reflects Section 8042 rescission and the SBIR/STTR transfer.

FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and the Blackswift testbed.

FY 2010
Decrease reflects minor program repricing.

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
SPC-01: SPACE PROGRAMS AND TECHNOLOGY	146.494	226.394	200.612						Continuing	Continuing

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 that combines 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	12.833	3.134	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. *FY 2008 Accomplishments:* - Developed and fabricated a mosaic of Charge-coupled devices (CCDs) to form a curved focal surface array. - Designed and fabricated a telescope enclosure and supporting infrastructure at White Sands Missile Range. - Integrated telescope elements at contractor facility. *FY 2009 Plans:* - Construct sensor subsystem. - Develop, test, and validate software for autonomous telescope operations and data reporting. - Complete processing of primary and secondary telescope mirrors. - Complete construction of telescope enclosure. - Integrate telescope elements on site. *FY 2010 Plans:* - Validate end-to-end telescope performance and surveillance operations.				
Novel Satellite Communications (NSC) (U) The aim of the Novel Satellite Communications (NSC) program was the development of a multi-user satellite communications (SATCOM) system that allows ground-based users with handheld radios to communicate with the satellite at high data rates, even when the users are close to multiple jammers and/or located in urban (i.e. severe multi-path) settings. This was accomplished through novel signal processing, communications and coding techniques. The NSC technology will transition to the Navy (SPAWAR) and Air Force Space and Missile Systems Center beginning in 2009.	.622	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Conducted additional experimental data collection and processing. - Finalized design of a post-transition NSC demonstration system. - Assessed performance potential with NSC applied to Navy MUOS (Multi-User Objective System) satellite ground stations. - Supported evaluation and transition of NSC technology.				
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 is planned for transition to the Air Force. *FY 2008 Accomplishments:* - Demonstrated lightweight technologies for system integration (i.e. high-energy density batteries, electronic circuits on thin-film barrier materials, advanced multi-purpose airship hulls, and regenerative fuel technologies). - Developed a conceptual design and fully-operational scaled flight system demonstrating complete system integration over an extended period.	29.034	78.400	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Conduct preliminary design review of demonstration system. - Develop and demonstrate calibration and compensation subsystem. - Demonstrate large-scale critical integrated subsystems. - Design radar resource controller for dynamically assigned aperture.				
Deep View (U) The Deep View program goal was to develop a high-resolution radar imaging capability to characterize objects in earth orbit, with special emphasis placed on imaging small objects at orbits ranging from low earth orbit to geosynchronous orbit. The approach was based upon a large aperture imaging radar system redesigned to operate at very high power over very broad bandwidth at W-band. Key technology development focused on: 1) transmitters capable of providing the required power to image at deep-space ranges over full bandwidth, and 2) an antenna design that maintains the necessary form factor over a very large aperture. The program concluded following completion of a power combining test of three gyro-twystron tubes in a single sub-band. The Deep View technologies have transitioned to the Air Force. *FY 2008 Accomplishments:* - Demonstrated gyro-twystron power combining to establish diplexer performance. - Provided developed technologies to the Air Force for transition into its radar program of record.	.730	.000	.000	
Long View (U) The Long View program developed an inverse synthetic aperture laser radar (LADAR) that enabled the high-resolution imaging of geostationary satellites when coupled to a large aperture telescope. Specifically, the technologies developed in the Long View program were an optical reference oscillator that is stable over the propagation time to a geostationary satellite (GEOSTAT) and back (about a quarter of a second) and autofocus algorithms that restore image quality that has been degraded due to atmospheric turbulence and optical reference oscillator instability over the imaging time (about 100 seconds). These two technologies are required in order to make inverse synthetic aperture LADAR systems feasible for objects in geostationary orbits.	3.809	.000	.000	

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<tr><td colspan="5">Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification</td><td colspan="2">DATE: May 2009</td></tr>
<tr><td>APPROPRIATION/BUDGET ACTIVITY
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)</td><td colspan="4">R-1 ITEM NOMENCLATURE
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</table>

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Demonstrated that the stable optical reference oscillator meets stability requirements. - Demonstrated that the autofocus algorithm is capable of eliminating the blurring due to atmospheric turbulence and stable optical reference oscillator instability over the imaging time. - Investigated applicability of Long View technologies for other orbits. - Made technologies available to the Navy for transition.				
Falcon (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. Technologies developed under Falcon would also allow for a low cost, responsive Small Launch Vehicle (SLV) capable of launching small satellites into low earth and sun synchronous orbits and will provide the nation a new, small payload access to space capability. 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. The effort has been jointly funded with the Office of Secretary of Defense Global Strike program office in FY 2008 and FY 2009. Falcon capabilities are planned for transition to the Air Force in FY 2010. *FY 2008 Accomplishments:* - Constructed a second horizontal test stand (HTS) for Phase 2C testing with more instrumentation. - Refurbished the vertical test stand (VTS) with new propellant tanks and instrumentation. - Redesigned the injector to address the instability and thermal issues from Phase 2B.	25.000	25.000	14.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Conducted hot fire system-checks using the new Phase 2C engine on the HTS. - Conducted critical design review of HTV-2 demonstration system. - Initiated assembly, integration, and testing (AI&T) of two HTV-2 vehicles. - Continued assembly and modification of two Minotaur IV Lite launch vehicles. - Completed twenty-seven, twenty second hot fire tests on the new HTS. - Completed three long-duration hot fire tests on the new VTS. - Fully characterized the VaPak engine and assessed its performance. *FY 2009 Plans:* - Complete AI&T of two HTV-2 vehicles. - Conduct flight test of first HTV-2 vehicle incorporating next generation hypersonic technologies. *FY 2010 Plans:* - Conduct flight test of second HTV-2 vehicle demonstrating increased thermal environment and cross-range capability.				
Mode Transition (MoTr) Demonstration (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 Falcon combined-cycle engine technology and the Air Force/ DARPA High Speed Turbine Engine Technology Demonstration (HiSTED) program. Beginning in FY 2010, this program will be funded in PE 0603286, Project AIR-01, Advanced Aerospace Systems. *FY 2009 Plans:* - Complete Falcon freejet testing. - Select a turbojet from the HiSTED program. - Complete preliminary design of a TBCC engine model. - Complete facility assessment study to select a primary facility.	.000	10.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Complete preliminary design of primary facility modifications.				
Satellite Program for Instant Depletion of Energetic Radiation (SPIDER)* *Formerly Sleight of HAND (SOH). (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) is a proof-of-concept demonstration of the technology and techniques to rapidly mitigate the HAND-enhanced trapped radiation within days of a HAND event, before LEO spacecraft capabilities are degraded. Other proposed remediation methods are slower, taking weeks or months versus days, and would result in spacecraft degradation and would require asset replacement. The SPIDER program will use a satellite-based neutral gas release to generate plasma waves over a large region of the trapped radiation belts. Trapped electrons will experience plasma wave induced accelerations and pitch angle scattering. Pitch angle scattering causes the harmful electrons to be precipitated out of the radiation belt and neutralized in the earth's atmosphere. Complementary efforts will include the development of an end-to-end model and the development of techniques to measure and probe the state of the ionosphere, particularly the population density of trapped high energy electrons. Following modeling and analysis, laboratory proof-of-concept experiments and a risk reduction sounding rocket flight, a space-based demonstration will be pursued as a pathfinder for a future program to develop an operational radiation belt remediation capability. Potential transition partners include the Navy and Air Force. *FY 2008 Accomplishments:* - Performed detailed modeling and analysis of neutral gas release approach to determine the potential efficiency of the high energy electron remediation process. - Used results of ground-based SPIDER experiments to enhance requirements for a space-based SPIDER demonstrator.	12.710	17.000	31.800	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop conceptual design for the on-orbit space demonstration. - Prepare for risk reduction sounding rocket flight. *FY 2010 Plans:* - Perform risk reduction sounding rocket flight, evaluate results, and incorporate into proposed demonstration. - Develop system requirements and conduct system requirements review and develop preliminary design.				
RAD Hard by Design (U) This program is developing, characterizing, and demonstrating 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 is pursuing development of design-based technologies that will 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, which is anticipated to be completed by FY 2009. 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 2008 Accomplishments:* - Identified candidate system-on-a-chip integrated circuit (IC) to harden utilizing the RHBD standard cell libraries previously developed by this program.	4.720	3.705	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Fabricated "intermediate" demonstration IC as preliminary to the complete RHBD version of the system on chip (SOC) above. - Began exploration of 65 nanometer (nm) technology with respect to RHBD methods. - Began exploration of silicon on insulator (SOI) technology with respect to RHBD methods. *FY 2009 Plans:* - Fabricate and test "final" RHBD demo ICs chosen in FY 2008 (90 nm complementary metal oxide semiconductor (CMOS) technology). - Complete investigation of RHBD efficacy in 65 nm CMOS technology. - Complete investigation of RHBD efficacy in SOI technology.				
Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) (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 environment, 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.	8.875	5.750	3.312	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Completed initial examination of micro-propulsion technologies. - Studied the use of large composite structures for pico and nanosatellite use. *FY 2009 Plans:* - Conduct system design trades of appropriate technologies. - Perform mission utility assessments and feasibility studies and develop concepts of operation. *FY 2010 Plans:* - Design and develop microsatellite system concepts and integrate selected technologies. - Perform component and subsystem ground tests.				
System F6 (U) The goal of the System F6 program is to demonstrate a radically new space system composed of a heterogeneous network of free flying or loosely connected small satellite modules that will, working together, provide at least the same effective mission capability of a large monolithic satellite. Current large space systems used for national security purposes are constrained due to their monolithic architecture. They can be launched only on a small number of large launch vehicles, cannot readily be upgraded and/or reconfigured with new hardware on-orbit, and are risk-intensive, since the unforgiving launch and space environments can result in a total loss of investment with one mistake. The System F6 will partition the tasks performed by monolithic spacecraft (high bandwidth communications downlink, information processing, data storage, navigation, power, etc.) and assign each task to a dedicated small or micro satellite. This new fractionated space system architecture offers the potential for reduced risk, greater flexibility (e.g., on-orbit maintainability, scalability, adaptability, evolvability), enhanced robustness (e.g. survivability to attack, decreased mission impact due to launch vehicle failures), payload isolation, and faster deployment of initial capability. This program will develop, design, and test new space system architectures and technologies required to successfully decompose a conventional spacecraft into fundamental elements. Such architectures include, but are not limited to: robust, self-forming, and reliable networks; ultra-secure wireless data communications; dynamically reconfigurable service oriented distributed computing systems; wireless power systems; autonomous cluster navigation systems;	21.095	44.675	92.700	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
distributed payload approaches; and reliable, robust, rapidly re-locatable ground systems. The anticipated transition partner is the Air Force. *FY 2008 Accomplishments:* - Developed a conceptual design and fractionated system concepts, and integrated selected technologies. - Formulated econometric value-modeling methodologies to inform system engineering trade decisions. - Conducted Hardware-In-the-Loop (HIL) demonstrations of successively greater capability simulating a wireless network operating environment for fractionated satellite systems. - Developed trajectories for launch, deployment, and sustainment of cluster satellite systems. - Reviewed feasibility of wireless power transfer approaches for inter and intra-satellite operations. *FY 2009 Plans:* - Develop a preliminary design of the on-orbit demonstration system. - Perform component and subsystem ground tests. - Conduct 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. - Refine 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. - Build and/or modify mechanical and electrical test support systems in preparation for assembly and test of flight demonstration system spacecrafts. - Initiate construction of flight demonstration system spacecraft.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Front-end Robotics Enabling Near-term Demonstration (FREND)	9.100	11.950	7.000	

(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. Recent events have significantly increased the number of objects 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 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.

FY 2008 Accomplishments:
- Procured and fabricated flight hardware for integration and testing.
- Conducted robotic payload ground test.
- Tested control schemes in 1G (earth's gravity) environment.
- Conducted hardware-in-the-loop testing of flight hardware in proximity operations test facility.
- Assessed applicability of neurorobotic technologies to the FREND robotic payload.

FY 2009 Plans:
- Work with mission partner to develop demonstration mission.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Conduct Conceptual Design Review of FREND-based servicing spacecraft with potential mission partners. - Conduct 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. - Initiate studies of LEO debris solutions.				
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, 20kW scalable to 80kW or more. The specific power goal is 130 W/Kg yielding an ultra light-weight power system of approximately 150 Kg for a 20kW 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 2008 Accomplishments:* - Conducted preliminary design and technology selection.	7.000	10.730	14.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Perform detailed design, development, and ground testing of the FAST spacecraft high-power generation subsystem. - Demonstrate mechanical deployment of full-scale solar concentrator and heat rejection system in 1G environment. - Initiate design and development of the FAST demonstrator spacecraft. *FY 2010 Plans:* - Integrate FAST high-power generation subsystem with demonstrator spacecraft.				
NanoPayload Delivery (NPD) (U) The NanoPayload Delivery (NPD) program studied the technical feasibility of ultra-lightweight, rapid-response spacecraft delivery from land, sea, or air-based platforms. Such nanopayloads (1-10 kilograms) could be boosted to low earth orbit (200 km altitude) in a matter of hours following call-up. The program examined the use of ongoing technology development efforts, which permit the fabrication of microscale pumps, thrust chambers, and valves. Such rocket engines, which are theoretically capable of thrust-to-weight ratios of 100:1 or greater, would allow for significant reductions in overall engine mass and permit nanosatellites to be placed in low orbits for several weeks to months. Delivery systems considered included: (1) a stock aircraft, such as the F-15E or F-16, (2) a truck-mounted erector, or (3) the deck of a small naval vessel. *FY 2008 Accomplishments:* - Surveyed existing aircraft-, land-, and sea-based missile platforms for compatibility with NPD mission constraints and requirements. - Designed, fabricated, and tested a micro chemical engine; including pumps, lines, valves, and thrust chamber to validate performance models.	2.966	.000	.000	
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	4.000	4.800	10.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Developed initial system requirements and design. - Developed list of applicable systems and identified relevant sources of data. *FY 2009 Plans:* - Conduct system trades and validate critical components. - Mature system parameters and operational procedures. *FY 2010 Plans:* - Develop algorithms and software required to integrate disparate information into a single framework. - Integrate software environment into a suite of visualization products that provide situational awareness and decision making tools.				
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 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	.000	1.750	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 Plans:* - Perform compact test range demonstration validating system concept and algorithms. - Complete design for a potential flight demonstration system. *FY 2010 Plans:* - Initiate final design plans for the flight demonstration system. - Complete subsystem technologies.				
Bi-Static Shield (U) The Bi-Static Shield program will utilize existing satellite tracking, telemetry and control (TT&C) antennas from NASA's Goldstone tracking site to illuminate geosynchronous (GEO) satellites. Using ground-based radio astronomy antennas located across the country to serve as bi-static receivers, reflections from small GEO intruder satellites will be processed to form 3-D images, useful for determining their function and threat potential. Use of existing satellite transmit antennas to generate a bi-static electromagnetic shield would demonstrate the utility of very important situational awareness capability without the need for additional on-orbit assets around individual satellites. The Bi-Static Shield program is planned for transition to the Air Force for space situational awareness applications.	.000	3.500	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Conduct modeling and simulation to determine algorithms required. - Assess availability of ground and space-based objects for concept demonstration. - Conduct proof-of-principle demonstrations of basic concept. *FY 2010 Plans:* - Conduct additional measurement campaigns on additional space-based objects. - Refine algorithms as required.				
High Delta-V Experiment (HiDVE) (U) The goal of the High Delta-V Experiment (HiDVE) program is to design, develop, and demonstrate a low-mass, low-volume, high delta-V solar thermal propulsion (STP) engine suitable for integration with approximately a 15kg nanosatellite host. The enabling technologies are very high-temperature materials and light-weight solar concentration systems. A HiDVE system will provide small satellites, historically constructed without propulsive capability, with substantial delta-V affording nanosatellites increased orbital range, in terms of both altitude and plane. In addition, this flexibility will be essential to future nanosatellite mission designers and operators, who will be able to take advantage of less-than-optimal insertion orbits and later move to an intended mission orbit. Specific objectives of the HiDVE program include: development and demonstration of a functioning STP system in a relevant environment; an operational test plan that outlines the steps needed to flight-qualify an integrated nanosatellite with an STP system. The Air Force is the expected transition partner. *FY 2008 Accomplishments:* - Developed a functioning high delta-V solar thermal propulsion system design for relevant environments. *FY 2009 Plans:* - Develop and ground demonstrate low-cost, low-volume solar thermal propulsion prototypes. *FY 2010 Plans:* - Integrate HiDVE prototype with nanosatellite host.	4.000	6.000	13.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
High Orbit Manufacture & Assembly of Space Structures (HiMASS)	.000	.000	6.800	

(U) The goal of the High Orbit Manufacture & Assembly of Space Structures (HiMASS) program is to mature and demonstrate the technology for lightweight, volumetrically efficient and affordable large space structures. Such structures autonomously deployed, assembled or manufactured on orbit can support a wide range of future military applications ranging from revolutionary intelligence, surveillance and reconnaissance (ISR) and communications to high power energy generation. For example, large apertures and supporting structures will enable migration of ISR assets from low earth orbit (LEO) to medium earth orbit (MEO)/geosynchronous orbit (GEO) enhancing survivability and dramatically improving persistence over theater, in some cases enabling continuous coverage. Similarly, GEO communications satellites with very large antennas and supporting structures can dramatically improve the quality and bandwidth of communications while radically reducing the size and weight of ground based antennas and communications equipment carried by the warfighter.

FY 2010 Plans:
- Develop HiMASS preliminary design, risk management plan, and technology and system maturation plan.

C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
Falcon/OSD	23.900	11.000	.000						Continuing	Continuing
Space Surveillance Telescope/USAF	.000	1.100	.000						Continuing	Continuing

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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	163.386	199.504	205.912						Continuing	Continuing
MT-07: CENTERS OF EXCELLENCE	4.000	7.000	.000						Continuing	Continuing
MT-12: MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY	34.975	64.015	77.963						Continuing	Continuing
MT-15: MIXED TECHNOLOGY INTEGRATION	124.411	128.489	127.949						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

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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 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 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	202.942	201.146	198.712	
Current BES/President's Budget	163.386	199.504	205.912	
Total Adjustments	-39.556	-1.642	7.200	
Congressional Program Reductions	.000	-15.442		
Congressional Rescissions	-10.500	.000		
Total Congressional Increases	.000	13.800		
Total Reprogrammings	-23.500	.000		
SBIR/STTR Transfer	-5.556	.000		
TotalOtherAdjustments			7.200	

Congressional Increase Details ($ in Millions)

	FY 2008	FY 2009
Project: MT-07, **Institute of Advanced Flexible Manufacturing Systems**	.000	7.000
Project: MT-15, **Center for Autonomous Solar Power Large Area**	.000	4.000
Project: MT-15, **Hybrid Power Generation System**	.000	1.200
Project: MT-15, **Ultra Low Power Electronics for Special Purpose Computers**	.000	1.600

Change Summary Explanation

FY 2008

Decrease reflects Section 8042 rescission, the AFRICOM reprogramming and the SBIR/STTR transfer.

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FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and new starts offset by congressional increases as identified above.

FY 2010
Increase reflects minor program repricing.

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MT-07: CENTERS OF EXCELLENCE	4.000	7.000	.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 2008	FY 2009	FY 2010	FY 2011
Advanced Flexible Manufacturing *FY 2008 Accomplishments:* - Assessed the Institute for Advanced Flexible Manufacturing's performance and worked toward transitioning from DoD to state/private support. *FY 2009 Plans:* - Continue to assess the Institute for Advanced Flexible Manufacturing's performance and work toward transitioning from DoD to state/private support.	4.000	7.000	.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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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603739E ADVANCED ELECTRONICS TECHNOLOGIES	MT-12

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 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	34.975	64.015	77.963						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The MicroElectroMechanical Systems (MEMS) 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) mass data storage; 5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Harsh Environment Robust Micromechanical Technology (HERMIT)	5.378	4.983	1.322	
(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 unprecedented performance, stability, and lifetime. Micromechanical RF switches are of particular interest,				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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; or 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 2008 Accomplishments:* - Demonstrated essential elements (e.g., thermistors, heaters, getters) needed for low power control of the operating environment surrounding a micromechanical device. *FY 2009 Plans:* - Demonstrate 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. - Demonstrate high yield MEMS RF switching component technologies that result in test devices that can operate for at least 100 billion switching cycles. Yield goals are to attain a 95% confidence that 99% of tested devices will meet 100 billion cycles. - Implement parallel measurement set-up to increase test throughput.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiate efforts for demonstrating the performance of RF switches in relevant radar applications. *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 2008 Accomplishments:* - Doubled the number of runs processed per year to achieve a goal rate of 500 runs per year. - Provided a modular merging process that combines modules together with transistor integrated circuits. *FY 2009 Plans:* - Insert 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.	2.651	2.700	1.876	
Low Power Micro Cryogenic Coolers (MCC)	3.507	1.810	1.480	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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. 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 2008 Accomplishments:* - Demonstrated micro-scale coolers capable of providing the needed cryogenic temperature while still fitting into a miniature size, with sufficient efficiency for low power operation. - Demonstrated heat exchangers, Joule-Thompson plugs, valves, pumps, all needed for cryo-cooler implementation. *FY 2009 Plans:* - Integrate micro cooler components together with sufficiently isolated devices to-be-cooled to yield a single chip system consuming very little power. *FY 2010 Plans:* - Improve MEMS-derived thermal isolation microstructures. - Develop improved thermoelectric materials for integration with existing and future MEMS.				
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	4.230	10.355	4.867	

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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 2008 Accomplishments:* - Developed technology to dramatically reduce bias drifts in Complementary Metal-Oxide Semiconductor (CMOS)-integrated MEMS accelerometers and gyros. - Developed CMOS-MEMS sensors for precision navigation aids such as velocity ranging and zero-velocity updating. *FY 2009 Plans:* - Reduce power and volume requirements. - Develop 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.					
Thermal Ground Plane (TGP) (U) The Thermal Ground Plane (TGP) program is developing high-performance thermal materials and substrates that will enhance the performance of many DoD systems by greatly improving the thermal path of the embedded electronics and Microsystems. The program will focus on the development of thin, large-area, high-thermal conductivity substrates for multi-chip modules (MCM). Innovations in heat pipes (i.e., wicking structures, working fluids, and casing materials) and related approaches exploiting two-phase fluidic cooling are being pursued to exploit the high thermal conduction, extreme reliability, and lack of moving parts or needs for external power, all critical for the intended application. Technology will be inserted through DoD industrial firms into future DoD systems.		6.081	12.597	10.931	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Developed baseline approach for incorporating new wicks, working fluids, and casing materials for application to MCM's. *FY 2009 Plans:* - Design, fabricate and perform experiments on TGP prototypes and complete initial thermal simulations. *FY 2010 Plans:* - Demonstrate the performance benefits of an integrated TGP through refining of wick materials and tuning the composition of the casing. - Demonstrate a full-performance TGP with enhanced thermal conductivity, hermeticity, and lifetime in a scaled-up 20 cm x 10 cm x <1mm sample.				
Integrated Primary Atomic Clock (IMPACT)* *Formerly titled Micro-Beam Clock. (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 2008 Accomplishments:* - Determined permanent magnet laser cutting at microscale. - Determined High B-field gradients at microscale.	2.000	9.970	8.521	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Determine pressure measurement in presence of high magnetic field with MEMS pressure sensors. - Identify retrace drifts and reduce 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.				
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 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. Possibilities of using mechanical power supplies and mechanical vibrating clocks could enable electronics that are less susceptible to electromagnetic pulse attacks. Enabling of 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 2008 Accomplishments:* - Developed mechanical gain elements for analog amplification using effects such as buckling and electromechanical phase changes. *FY 2009 Plans:* - Develop NEMS switches in direct bandgap materials to enable optical functionality with switches.	7.632	7.916	8.338	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Demonstrate NEMS devices and technologies for microcontroller building blocks - adders, counters, memories, that can operate at very high temperatures.				
Information Tethered Microscale Autonomous Rotary Stages (ITMARS)* *Formerly titled NanoCAD. (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 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 Plans:* - Initiate efforts to implement power and information to microscale rotating stages, for various applications. *FY 2010 Plans:* - Develop prototype applications.	.000	4.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Reduce bias levels in sensors, increase directivity in directional sensors, and achieve mechanical phased arrays.				
Microtechnologies for Air-Cooled Exchangers (MACE) Heat Sink Enhancement	2.384	5.684	11.813	
(U) The Microtechnologies for Air-Cooled Exchangers (MACE) Heat Sink Enhancement program is developing and demonstrating technologies for creating air-cooled heat exchangers that offers significant performance enhancements over conventional heat rejection systems. The technologies developed under this program will allow the DoD to replace expensive cooling technologies such as spray-cooling and refrigeration with much simpler, low cost air-cooled exchangers without penalties in thermal performance. The program will transition via industrial performers. *FY 2008 Accomplishments:* - Created initial simulation models to gain insight to complex thermal phenomena across multiple interfaces and surfaces. *FY 2009 Plans:* - Complete experiments and analyses of technologies and implementation approaches to enhance the performance and efficiencies of air-cooled exchangers. - Construct preliminary models detailing scaling and embodying new physics of complex flows. *FY 2010 Plans:* - Fabricate and test a ‘single-fin’ heat sink device. - Scale up prototype air-cooled exchangers to a large, full-format heat sink.				
Chip-Scale Spectrum Analyzers (CSSA)	.000	.000	4.005	
(U) The Chip-Scale Spectrum Analyzers (CSSA) program will use microresonators to accept very narrow channels of the radio spectrum while rejecting all others. The microresonator is designed to facilitate subsequent digitizing of the analog signal. A successful CSSA program would make possible a universal communications receiver that would be able to reconfigure and operate under any communication				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
standard, anywhere in the world. Future signal-capture environments will range from urban areas to outer space. The program will transition via industrial performers. *FY 2010 Plans:* - Improve rejection of unwanted signals while minimizing impedance. - Match resonators to analog-to-digital converters.				
Chip-Scale Vacuum Micropumps (U) The ability to efficiently distribute fluids throughout certain types of microsystems and to provide on-chip vacuum capabilities for various technologies is critical to the performance of many microsystems, including micro mass spectrometers, nanoscale detectors, RF resonators, and vacuum microelectronic components. Although microscale pumps have been developed by a number of research groups, many microsystems currently employ off-chip pumping because available microscale pumps cannot meet stressing application requirements. There is a pressing need for chip-scale micropumps with significantly improved performance (capable of operating at ~10^-6 Torr in a volume smaller than 1 CM^3). The MEMS Micropumps program will develop high-performance pumping capabilities critical to achieving an integrated, low-power microscale total analysis system and other complex electronic devices. The program will transition via industrial performers. *FY 2010 Plans:* - Develop methods to increase compression ratio and pump speeds to MEMS scales. - Decrease size of on-chip vacuum pumps.	.000	.000	4.000	
ChipScale Micromechanical, Efficient Deep-sub Wavelength Antennas (U) ChipScale Micromechanical, Efficient Deep-sub Wavelength Antennas will pursue development of integrated antennas directly on top of RF Complementary Metal-Oxide Semiconductor (CMOS) chips for optimal power transfer and impedance matching. MEMS high frequency resonators can be arrayed to generate an impedance matched surface to incident electromagnetic fields, while at the same time realizing differential detection by resonators that generate different phases at the incident frequencies. Scaling of resonators can be readily used to realize antennas tuned at different frequencies from kHz, MHz	.000	.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
to X-band, and at different quality factors for designable antenna efficiency and directionality. The program will transition via industrial performers. *FY 2010 Plans:* - Employ metrology data to predict device performance using nanoscale Computer Aided Design (CAD) tools, and apply tuning to achieve homogeneous.				
Nano Thermal Interfaces (NTI) (U) The primary goal of the Nano Thermal Interfaces (NTI) program is the development and demonstration of new technologies and concepts based on exploitation of novel materials and structures that provide significant reduction in the thermal resistance of the interface layer between the backside of an electronic device (chip) and the next layer of packaging. This interface is where considerable waste heat is dissipated and leads to thermal limitations in many electronic components. The NTI program will develop new materials and associated processes to serve as enhanced thermal interfaces that can provide consistent, reliable and stable thermal resistance throughout the life of DoD electronic systems. Materials with highly directional thermal properties and matched thermal coefficients will be investigated and utilized. Program transition will occur through industrial performers. *FY 2009 Plans:* - Investigate new approaches for the development and fabrication of high performance thermal interface materials. *FY 2010 Plans:* - Investigate novel materials and fabrication approaches for high-performance thermal interface materials with appropriate electronic materials and substrates.	.000	4.000	6.810	
Active Cooling Modules (ACM) (U) The Active Cooling Modules (ACM) program will enable greater power utilization margins in electronic materials while also increasing device reliability. Technologies developed will focus on lower temperature	.000	.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
operation of sensitive components, including operation below ambient temperatures. It will also leverage gains from other DARPA thermal and materials programs. *FY 2010 Plans:* - Design and build modules with all interfaces that demonstrate ACM benefits. - Reduce junction temperature for electronic devices.				
Chip-Scale Micro Gas Analyzers (U) The Chip-Scale Micro Gas Analyzers program utilized 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/biological agents. The use of MEMS technology also increased 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 faced in this program included 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 yielded sensors substantially more selective than conventional sensors, again, making them particularly suitable for detection and identification of airborne toxins. 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 2008 Accomplishments:* - Demonstrated MEMS-enabled, micro-scale separation columns, ionizers, electromagnetic field generators, vacuum pumps, gas sensor arrays, calibration sources, all needed for separation-based analyzers. - 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.	1.112	.000	.000	

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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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
MT-15: MIXED TECHNOLOGY INTEGRATION	124.411	128.489	127.949						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.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Adaptive Photonic Phased Locked Elements (APPLE)	12.314	6.792	13.000	
(U) The goal of the Adaptive Photonic Phased Locked Elements (APPLE) program is to demonstrate a fully scalable and modular architecture of phased sub-apertures capable of producing an arbitrarily large optical aperture that can be rapidly and non-mechanically steered over a wide field of regard with high precision. This effort is anticipated to transition via industry for potential laser systems and space based applications. *FY 2008 Accomplishments:* - Demonstrated the controlled combining of the outputs of multiple (7) small individual apertures at low input powers. - Demonstrated a small single aperture that could handle a high level of input laser power (200 Watts). *FY 2009 Plans:* - Demonstrate high power combined output of multiple (7) small individual apertures. *FY 2010 Plans:* - Demonstrate atmospheric compensation in the real atmosphere at low powers.				
Data in Optical Domain Network (DoD-Network)	9.539	3.693	2.000	
(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 will develop and demonstrate 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 will have two major areas of interest: the first will focus on developing new photonic technology that is essential if photonics				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
is to play a significant role in higher order processing in optical networks, the second area will focus 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 is anticipated to transition via industry to high speed, high capacity optical networking programs of interest to the Air Force. *FY 2008 Accomplishments:* - Demonstrated all-optical, Indium Phosphide (InP)-based, integrated photonic, packet forwarding chip which supports forwarding and re-labeling of optical packet headers. - Demonstrated the first fully monolithic separate absorption and modulation wavelength converter operating “error-free.” *FY 2009 Plans:* - Develop an all-optical data router (ODR) with high data rate ports. *FY 2010 Plans:* - Demonstrate an ODR with high-throughput, multiple input/output ports, high signal integrity, high signal-to-noise ratio and high scalability leading to an intelligent all-optical network. - Test interoperability of an ODR with electronic routers.				
High Operating Temperature - Mid-Wave Infrared (HOT MWIR) (U) The objective of the High Operating Temperature - Mid-Wave Infrared (HOT MWIR) program is 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 detection and for imaging from fast moving platforms. Technology goals are to achieve greater than an order of magnitude reduction in currents contributing to detector noise demonstrated with a high density, large area detector array format of up to 1280 x 720 elements. For imaging, the sensor will respond in a broad spectral band, including the mid and long wave infrared, and will be optimized for imaging at high frame rates with large field of view. This program is anticipated to transition via industry for applications such as multi-band mid-wave or micro-detectors.	14.405	10.374	9.126	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Demonstrated 256x256 arrays operating at 250 Kelvin with X8 – X10 lower dark current. - Established pixel design and test arrays for mega-pixel room temperature arrays. - Demonstrated high density arrays with dual band (mid/long wavelength infrared) response. *FY 2009 Plans:* - Demonstrate thermal array with novel pixel structure showing low thermal mass and reduction in low frequency noise. - Demonstrate mid-wave photon detector array with dark current reduced to be comparable to the current from background radiation. *FY 2010 Plans:* - Demonstrate large format mid-wave photon detector array operating at elevated temperature. - Demonstrate high pixel density broadband (mid-wave and long-wave) thermally sensitive array with fast thermal time constant to increase frame rate.				
Visible/Short Wave IR - Photon Counting (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 2008 Accomplishments:* - Demonstrated read-out integrated circuit for short wave infrared with less than 10 noise electrons.	7.297	1.004	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Integrated low noise focal plane array into a mega-pixel array format and demonstrated room temperature imaging. *FY 2009 Plans:* - Demonstrate single photon counting devices for ultra low noise imaging.				
Electronic & Photonic Integrated Circuits on Silicon (EPIC) (U) The Electronic & Photonic Integrated Circuits on Silicon (EPIC) program will develop two critical alternative photonic technologies based on silicon substrates. The first thrust addresses 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 first alternative technology development will be optical amplifiers using Raman gain. Fiber amplifiers based on Raman gain currently play a major role in optical networks, and demonstrating this optical amplification in silicon will be a major step toward overcoming on-chip losses in complex chip-scale optical components. The second alternative technology development will address optical transistor action, or switching, in silicon (i.e., a three-terminal optical device in which control photons at one terminal will make a large change in the photons transmitted between the other two terminals). Taken together, these two capabilities will create a new paradigm in which silicon will provide a platform for monolithic integration of photonic and electronic functions. The EPIC program is anticipated to transition via industry to optical communication and electronic warfare programs of interest to all Services. *FY 2008 Accomplishments:* - Demonstrated 40 gigabytes per second capacity transceiver chip with four wavelengths. - Demonstrated a wideband radio frequency channelizer with multiple channels and nulling of at least a single channel. - Increased integration complexity of electronics and photonics to include hundreds of photonics components.	5.866	1.125	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Demonstrate a functional Application Specific-EPIC using complementary metal-oxide semiconductor (CMOS) compatible processing.				
Space, Time Adaptive Processing (STAP) BOY (U) The Space, Time Adaptive Processing (STAP) BOY program will research, develop, and demonstrate 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). Success in this program will allow the DoD to exploit the continuing phenomenal growth in both performance and programmability of GPUs resulting from competition in the multi-billion dollar international electronic entertainment industry. Particularly relevant advantages of recent GPUs over more traditional embedded processors include enhanced memory access bandwidth, hardware-accelerated floating-point vector geometry functions, low power consumption, and open source programming language support. The STAP BOY technology will transition to the Army at the conclusion of Phase III. *FY 2008 Accomplishments:* - Demonstrated that the prototype system is capable of sustaining 100 giga floating point operations per second (Gflops) potentially scalable to a multi-GPU pipeline mesh teraflop computing architecture, and is easily programmable to provide extremely high performance in diverse challenge problems. *FY 2009 Plans:* - Develop and test military application prototypes utilizing STAP-BOY technology. - Develop a self-programming capability for this technology.	4.240	5.500	.000	
Analog Spectral Processors (ASP) (U) The Analog Spectral Processors (ASP) program will leverage 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 will enable proliferation of	4.325	9.028	6.289	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated intimate integration of filter and switch components. - Demonstrated pre-selector, intermediate frequency, and analog filter sensor banks. - Completed Conceptual Design Review. *FY 2009 Plans:* - Integrate filter banks with active components. - Conduct analysis of proposed front-end architecture. - Breadboard-level filter banks will be delivered to a third-party testing facility. *FY 2010 Plans:* - Demonstrate a complete Analog Spectral Processor front-end meeting size, power and performance objectives.				
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. (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	2.109	5.690	5.220	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Designed and implemented doubly resonant (RF and optical) antenna structures in support of non-electronic signal transduction. *FY 2009 Plans:* - Demonstrate 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.				
Microsensors for Imaging (MISI) (U) The Microsensors for Imaging (MISI) program establishes technology for extremely small, lightweight cameras sensitive in the short wave infrared spectrum for a wide range of applications. MISI is 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 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. In the micro-air vehicle application, the weight goal is ten grams (including the optics, detector and electronics) for a camera with a degree field of view and recognition range of 100 meters. In the head-mount application, the weight goal of 350 grams includes the sensor with display	4.428	4.917	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
and power source. This program will transition through industry performers into DoD systems, allowing integration into small robotic platforms and micro-air vehicles. *FY 2008 Accomplishments:* - Demonstrated imaging arrays in micropackage for both man-portable and micro-vehicle applications, with package thermal stability for long-lifetime operation. - Completed design of short wave arrays for helmet mounted applications compatible with illuminator and compact system design. *FY 2009 Plans:* - Demonstrate megapixel arrays in micropackage that amplify low level optical signals with minimum excess noise while maintaining uniformity across the array. - Demonstrate operation at room temperature over military temperature range.				
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 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 2008 Accomplishments:* - Designed, built, and integrated a demagnification optics system and wafer adapter, and achieved a patterning resolution on the wafer of about 1 micron. - Characterized prototype Reflection Electron Branch Lithography (REBL) system to validate simulation results.	24.700	19.000	27.100	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Demonstrate rotary stage at 10 meters per second. - Demonstrate static imaging on prototype REBL system. - Demonstrate 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.				
Stand-off Solid Penetrating Imaging (U) The Stand-off Solid Penetrating Imaging program detected and identified explosive threats at a stand-off distance, a critical requirement for force protection in all military operations, especially in urban scenarios. Using a microsystem approach, it identified and exploited significant attributes from multiple non-over-lapping perspectives, such as shape and chemical signature, at stand-off ranges of fifty meters to potentially one hundred meters. *FY 2008 Accomplishments:* - Assessed X-ray source requirements, such as power, size, weight, focal spot, and tube configuration including various beam formation techniques. - Implemented X-ray imaging reconstruction for remote vehicle applications.	2.542	.000	.000	
Deep Ultraviolet Avalanche Photodetectors (DUVAP) (U) This program will demonstrate avalanche photodiodes (APDs) operating in the Geiger mode, i.e. capable of counting single photons with high gain. The APDs will operate in the ultraviolet, in the band centered at 280 nanometers (nm), and will be designed to be insensitive to the solar flux. The two classes of materials being pursued are 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	3.833	1.139	1.720	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Demonstrated Geiger mode operation of an APD at 280 nanometers. - Determined maximum defect density for stable avalanche gain. *FY 2009 Plans:* - Demonstrate integrated solar-blind ultraviolet filter with appropriate cutoff. - Optimize materials for low defect density and reproducible device yield. *FY 2010 Plans:* - Demonstrate a large array of Geiger mode APDs with dark count rate < 10 kilohertz (kHz) and high solar rejection ratio (over 1,000,000).				
Ultradense Nanophotonic Intrachip Communication (UNIC) (U) The goal of the Ultradense Nanophotonic Intrachip Communication (UNIC) program is 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. Technical challenges that must be met include: high precision, low loss nanophotonic circuit fabrication; low cost fabrication methods; high performance nanoscale modulators; detectors, multiplexers and demultiplexers; architecture for addressing ultra-dense systems; and techniques for efficient high capacity/bandwidth I/O of data to and from the chip. This technology will transition via industrial performers developing faster and more complex processing such as real-time pattern matching, target recognition, image processing and Terahertz (THz) class command-and-control networks. *FY 2008 Accomplishments:* - Created novel designs to demonstrate extremely low power complementary metal-oxide-semiconductor (CMOS) compatible silicon photonic devices.	3.127	10.950	11.970	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Demonstrate 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. - Integrate arrays comprised of 4-wavelength silicon photonic transmitters and 10 gigabytes/second receiver. *FY 2010 Plans:* - Demonstrate integrated arrays of 4-wavelength silicon photonic transmitters and receivers operating at 10 gigabytes per second (Gbps). - Demonstrate feasibility of 1.5 per Joule/bit interconnect link energy budget for silicon photonic optical data link, based upon fabricated arrays. - Demonstrate wavelength division multiplexed routing through 2 physical layers at 10 Gbps and less than one part in a trillion bit error rate (1E-12 bit error rate).				
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. *FY 2008 Accomplishments:* - Developed high efficiency detector materials. - Demonstrated curved single pixel detector.	8.386	6.575	6.519	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop improved materials for Visable-Near IR-Shortwave IR (VIS-NIR-SWIR). - Demonstrate 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.				
Dual-Mode Detector Ensemble (DUDE)* *Formerly titled Day/Night Adaptive Imager. (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 for each long wave pixel, and evaluated for rifle sight applications. The technology will transition via industry upon successful completion of the program. *FY 2008 Accomplishments:* - Developed ultra-wide dynamic range imaging sensors that count individual photon events and also operate in high light level.	3.500	5.000	7.834	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Reduce dark counts for room temperature operation. - Demonstrate 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.				
Nyquist-Limited Infrared Detectors (NIRD)* *Formerly High Resolution Short Wave Infrared/High Density Infrared Retina. (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.	.000	3.800	5.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**		**DATE:** May 2009
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 NUMBER** MT-15

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Develop new detector approaches for high pixel density with passivation processes to control surface leakage, which will dominate small detectors. - Demonstrate test structures with detector size approaching two microns and show contact method to small pixel structure. - Conduct feasibility study incorporating the results from the static runway measurements, outside data collection sources, and dynamic flight tests. - Develop 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.				
Photon Trap Structures for Quantum Advanced Detectors (P-SQUAD) (U) The objective of Photon Trap Structures for Quantum Advanced Detectors (P-SQUAD), which was previously funded as part of the Nyquist-Limited Infrared Detectors program, 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 Plans:* - Fabricate 16 x 16 detector arrays using nano-pillar arrays. - Validate P-SQUAD structure design characteristics using experimental and theoretical models. *FY 2010 Plans:* - Demonstrate a 640 x 480 array that is fully integrated with readout processor.	.000	4.518	7.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Validate P-SQUAD integrated array design.				
Disruptive Manufacturing Technologies (DMT) (U) The goal of the Disruptive Manufacturing Technologies (DMT) program is 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. The DMT program will merge Polystrata (Registered Trademark) and GaN technologies to eliminate the need for monolithic microwave integrated circuits (MMICs). The direct product replacement transition candidate for this program is the TWTA power amplifier output stage in the AN/ALE-55 Fiber Optic Towed Decoy for the Navy's new F/A-18 E/F Super Hornet, and the Air Force B1-B and F-15 platforms. It will be replaced with solid-state hybrid microwave integrate circuit (HyMIC) modules developed by merging Polystrata and gallium nitride (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. Beyond developing a replacement for TWTAs, HyMIC technology promises to increase adoption of high performance millimeter wave (MMW) systems employing mature III-V technologies as well as advance earlier adoption of those using nascent III-V technologies. The program will transition into the joint Navy-Air Force IDECM program. *FY 2008 Accomplishments:* - Demonstrated flip chip mounting on Polystrata structures. - Completed proof-of-concept GaN 20 watts (W) module implemented with Polystrata technology, along with a passive element library to enable development of the 57 W GaN building block. *FY 2009 Plans:* - Demonstrate a form-fit-function 160 W GaN amplifier ready for insertion into the IDECM decoy module. *FY 2010 Plans:* - Demonstrate 57 W GaN HyMIC building block.	4.368	2.392	1.418	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Continue to demonstrate a form-fit-function 160 W GaN amplifier (TWTA replacement) ready for insertion into the Integrated Defensive Electronic Countermeasures (IDECM) decoy module.				
COmpact Ultra-stable Gyro for Absolute Reference (COUGAR)* *Previously reported in PE 0603768E, Project GT-01. (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 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. *FY 2009 Plans:* - Develop purely single-polarization low-loss, low glass-content BGOF. - Demonstrate compact narrow line-width single-frequency laser technology with ultra-low jitter and the capability of extremely linear frequency scanning. - Develop resonator-ready (low-loss) PCEs for mitigating residual non-linear Kerr Effect errors and relaxing tolerances on laser intensity stabilization requirements. - Develop 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.	.000	5.761	7.285	
Gratings of Regular Arrays and Trim Exposures (GRATE)* *Formerly Cost Effective Low Volume Nanofabrication.	.000	4.448	6.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

(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 Plans:
- Develop 1D-Designs and Patterning Methods.
- Evaluate 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.
- Verify efficacy of 1D design approach. Quantitative benefits of 1D vs traditional 2D design approach. 2D to 1D conversion of legacy design IP.
- Develop 1D design enabling process extensions such as "trim/stitch" and "frequency doubling". 1D test cell fabrication.
- Study feasibility of custom grating fabrication tool based on interference lithography.

FY 2010 Plans:
- Develop 1D Fabrication Demos.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop 1D standard cell library for digital designs at < 32 nm node. 1D computer aided design tool development. - 1D fabrication demos including various circuit elements making use of 1D-specific process extensions. - Demonstrate 1D circuit patterns using trimmed interference lithography.				
Room Temperature Spintronics-Based Logic (Spin Logic) (U) The goal of the Room Temperature Spintronics-Based Logic (Spin Logic) program is to develop room temperature logic devices based on magnetic spin. In current logic devices, the ultimate speed is limited by the heat that can be removed from the chip. The current microchip technology has been shown to be highly optimized for efficiency and no significant decreases in energy per logic step are possible outside of those already on the technology roadmap. Devices based on magnetic spin would not be based on the movement of electrical charge and can therefore operate at a reduced energy cost per logic function while retaining the performance of the current technology. It is expected that the Spin Logic program will lead to both higher performance logic chips, and lower power electronics. *FY 2010 Plans:* - Explore techniques to efficiently generate, manipulate and detect magnetic spin waves.	.000	.000	5.000	
Advanced Photonic Switch (APS) (U) The objective of the Advanced Photonic Switch (APS) program (an outgrowth of the Ultradense Nanophotonic Intrachip Communication (UNIC) 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 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	2.063	1.930	1.468	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 2008 Accomplishments:* - Finalized the design and operation of the first generation of Nanophotonic Optical Broadband Switches (NOBS). - Completed physical design activities for first generation NOBS and initiated fabrication of masks. *FY 2009 Plans:* - Complete fabrication of prototype NOBS devices to create a 2x2 array. - Design, fabricate, and test 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.				
Channelized SIGINT and ELINT Receiver for UAV Applications (ChaSER) (U) The objective of the Channelized SIGINT and ELINT Receiver for UAV Applications (ChaSER) study was to design, develop, and characterize a photonic Radio Frequency (RF) receiver front-end to reduce the size, weight and power (SWAP) of Electronic Support Measures/Electronic Counter Measure (ESM/ECM) systems by 100,000 times while maintaining or improving RF performance levels. *FY 2008 Accomplishments:* - Initiated the development of a highly sensitive, ultra-light, ultra-wideband, radar intercept and location system.	3.472	.000	.000	
Ultra Low Power Electronics for Special Purpose Computers	1.040	1.600	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) This program is developing advanced computing technology utilizing very low power electronic devices. *FY 2008 Accomplishments:* - Developed low power nanoscale electronics for special purpose computers. *FY 2009 Plans:* - Continue low power nano scale electronics development.				
Computing and Nanoscale Electronic Processing (U) The main objective of this program was to explore computing and nanoscale electronic processes. *FY 2008 Accomplishments:* - Developed new applications for nanoscale electronics.	1.200	.000	.000	
Center for Autonomous Solar Power (U) The objective of this program is to develop autonomous solar power flexible arrays. *FY 2009 Plans:* - Initiate solar power development.	.000	4.000	.000	
Adverse Weather Landing System (U) The goal of the Adverse Weather Landing System program is to provide the military pilot with an enhanced visual situational awareness capability to assist in making landing approaches in adverse 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.	1.657	2.250	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2008 Accomplishments: - Collected and analyzed limited visibility data from a variety of sources to develop requirements for a high resolution landing camera system. - Upgraded calibration systems to reduce pattern noise in the infrared (IR) sensors to be used in an operational system for various conditions (haze, sand, fog, snow, and rain). *FY 2009 Plans:* - Conduct feasibility study incorporating the results from the static runway measurements, outside data collection sources, and dynamic flight tests. - Develop requirements to support the development of a high resolution sensor pertinent to limited visibility flight operations.				
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 (a follow on to the Ultra-Wide Band Technology program) aims to 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. 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. 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 Plans:* - Fabricate and demonstrate a STAR module which exhibits high T/R isolation over a multi-octave 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.	.000	5.803	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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.				
Hybrid Power Generation System (U) Objective of this program is to advance and explore new hybrid power technologies. *FY 2009 Plans:* - Explore hybrid power technologies.	.000	1.200	.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-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	242.540	328.073	293.476						Continuing	Continuing
CCC-01: COMMAND & CONTROL INFORMATION SYSTEMS	64.899	41.887	61.630						Continuing	Continuing
CCC-02: INFORMATION INTEGRATION SYSTEMS	95.411	139.966	91.301						Continuing	Continuing
CCC-CLS: CLASSIFIED	82.230	146.220	140.545						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, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	255.235	338.964	283.277	
Current BES/President's Budget	242.540	328.073	293.476	
Total Adjustments	-12.695	-10.891	10.199	
Congressional Program Reductions	.000	-10.891		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	-5.707	.000		
SBIR/STTR Transfer	-6.988	.000		
TotalOtherAdjustments			10.199	

Change Summary Explanation

FY 2008
Decrease reflects the AFRICOM reprogramming and the SBIR/STTR transfer.

FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and execution delays.

FY 2010
Increase reflects additional funds in the Classified Project; offset by completion of situational awareness and communications efforts in Projects CCC-01 and CCC-02.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603760E COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS	CCC-01

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CCC-01: COMMAND & CONTROL INFORMATION SYSTEMS	64.899	41.887	61.630						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 2008	FY 2009	FY 2010	FY 2011
Heterogeneous Airborne Reconnaissance Team (HART)* *Formerly Heterogeneous Urban Reconnaissance Team (HURT). (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/	5.000	4.000	7.901	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
platform assignments algorithms. The technology presents mission status and future courses of action 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 2008 Accomplishments:* - Expanded capability to include taskable (gimbaled) sensors on manned aircraft. - Added infrared sensor and georegistration capabilities that were demonstrated during live flight testing at Ft. Hunter Liggett. - Developed, tested and deployed new georegistration algorithms for a specific large format mapping electro-optical sensor that has improved resolution for wide area missions, and reduced processing timelines while simultaneously doubling area coverage. - Integrated with the Army's Tactical Airspace Integration System (TAIS) and Collection Management Tool (CMT) to assist with airspace integration, automatically identify seams, and fill gaps in sensor coverage. *FY 2009 Plans:* - Support user training operations at Ft. Bliss/Ft. Hood. - Train and field test with the Army Evaluation Task Force (AETF) to identify other capabilities ready for rapid transition. - Extend operational area via unmanned aerial vehicle (UAV) communications relay with a 99% assured tactical downlink. - Add moving target indicator (MTI) for target tracking. - Provide dynamic overwatch to mobile warfighters by adapting flight paths, sensor and communications footprints, and by planning for UAV handoffs. - Demonstrate cooperative planning and handoff between multiple HART control centers. - Demonstrate HART interoperability with service airspace management and imagery dissemination systems. - Expand HART capability to Warrior and additional rotorcraft (FireScout and micro air vehicle (MAV)).				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Test and demonstrate cooperative interaction with 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 Future Combat Systems (FCS)/Command and Control of Robotic Entities (C2ORE)/ Future Force Integration Directorate (FFID) to integrate and transition full capabilities into 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.				
Deep Green* *Previously this was part of Advanced Tactical Battle Manager. (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.	14.785	16.887	19.282	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Developed initial Deep Green subsystems/components including Crystal Ball, which assembles a diverse set of candidate plans and provides an integrated probabilistic overlay for all. - Developed initial Commander's Associate, which induces the commander's intended plan from multi-modal man-machine dialog. - Developed initial SimPath, a fast multi-resolution combat model that enables high quality playoffs across the portfolio of planning options. *FY 2009 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. *FY 2010 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. - Begin the process of transitioning Deep Green technologies to fielded battle command systems.				
Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis)* *Previously this was part of Urban Commander. (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	5.033	9.000	13.750	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 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 in FY 2012. *FY 2008 Accomplishments:* - Initiated system engineering studies and design of ULTRA-Vis subsystems and interfaces. *FY 2009 Plans:* - Develop see-thru display conformal visor using holographic waveguide. - Develop optically-assisted navigation for continuous geo-location and pose estimation. - Develop 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 as 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.				
Collision Avoidance & Dynamic Airspace Control (CADAC)	4.000	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The goal of the Collision Avoidance and Dynamic Airspace Control (CADAC) program is to maximize airspace utilization through dynamic military airspace management. Today's labor-intensive human centric airspace management processes result in an inefficient use of airspace, limit the density and responsiveness of airborne systems, and have a large forward footprint. Further, the introduction of unmanned aircraft has increasingly complicated the challenge, leading to operating constraints and a realized growing potential for mishaps related to the different characteristics of manned and unmanned systems. This program will evaluate and develop technologies for automated and distributed systems that efficiently manage all objects in the airspace to include munitions, manned and unmanned aircraft. Specifically focused on the needs of the military, the program will deliver provable levels of safety while ensuring military freedom of maneuver. The automated system will be developed as a replacement for current management systems and processes, and may also be employed locally to augment existing systems in complex mixed civil / military environments. It will seek to enable highly automated integration of multi-source information and control to support tightly coupled air/ground/surface operations centered on small-unit unconventional forces. Challenges to be addressed include trusted algorithms, networked information exchange with uncertainty, and integration of legacy, degraded and intentionally disruptive aircraft. The program will also explore novel concepts of operation enabled by radically enhanced airspace utilization. The capabilities developed by this program will benefit all of the Services. *FY 2008 Accomplishments:* - Conducted multiple technology and feasibility analyses. - Developed and simulated candidate system architecture models. - Demonstrated the small Unmanned Aircraft System (UAS) cooperative CADAC component concept.				
Advanced Tactical Battle Manager (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 also provides support for combined operations employing dismounted soldiers, manned platforms, and autonomous vehicles through a graphical interface with unit commanders and extends plans by applying adversarial reasoning techniques to identify vulnerabilities and opportunities in the predicted enemy course of action.	2.000	3.000	6.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Finally, it examines modifications or counteractions to reduce vulnerabilities. Products will transition to the Services. (U) The Know What Is to Know Subsystem (KWIKS) develops 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 the forms and priorities of additional collection needs. This tool will provide automated assistance to the process of collections planning, which currently includes manual steps such as analysis of external context, enemy and neutral goals and capabilities, and assessment of known threats. It will support real-time planning of intelligence, surveillance and reconnaissance (ISR) assets, leveraging outputs of automated exploitation capabilities. The overall benefit is more effective, rapid, complete identification of the enemy's state and responsive planning of limited collection assets, resulting in achieving mission objectives with fewer friendly casualties and lower collateral damage. (U) The Cognitive Design and Management for Agile C2 (CODe-MAC2) will 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 the responsibilities, relations, tasks, priorities, and information sharing to meet 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. In response to the resulting challenges, the DoD has identified C2 as one of the areas where new, unconventional structures are needed to meet the new realities of today's operations and missions, 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 2008 Accomplishments:* KWIKS - Identified emerging computational techniques for analysis of information state under conditions of adversarial concealment and deception and partial observability.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Identified a series of realistic wargame-based experiments to enhance and validate the capabilities of the system. *FY 2009 Plans:* KWIKS - Identify integration environment and develop system capabilities to match transition needs. - Explore initial algorithmic approaches to translating commander's information needs to tangible targeting decks. *FY 2010 Plans:* KWIKS - Develop and evaluate via simulation KWIKS system solutions. - Conduct laboratory tests and obtain user feedback. CODe-MAC2 - Provide predictive and diagnostic estimation of C2 performance for alternative resource, relation, task, and information structures.				
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. This capability 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 the Personalized Assistant that Learns (PAL) program (funded in PE 0602304E, Project COG-02) that are ready for application to command and control and situational awareness systems.	5.000	7.000	14.197	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

(U) Efforts to integrate PAL 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 PAL software framework will provide a basic PAL application that can be customized by an application developer in a relatively straightforward fashion.

FY 2008 Accomplishments:
- Developed initial prototypes of cognitively-enhanced versions of operational systems suitable (e.g., certifiable) for use on military networks.
- Created an initial PAL Learning Services Framework – a library of basic learning algorithms, structured learning ensembles, and ready-to-go learning applications – that can be used by 3rd party application developers to insert PAL learning technology into existing or developing software applications.

FY 2009 Plans:
- Develop and refine 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.
- Demonstrate, test, and evaluate PAL-enhanced information systems in military exercises to validate that the PAL technologies are robust to the dynamics and uncertainties of the battlefield and dramatically compensate for end-user "cognitive overload".
- Harden and release 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.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Evolve and improve the PAL Learning Services Framework based on developer feedback.				
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 alert processing. 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. *FY 2008 Accomplishments:* - Demonstrated that individual and class-of-vessel motion-based activity patterns can be learned automatically from long-duration tracks. - Used learned patterns to predict future behavior and detect deviations from normal behavior. - Automatically processed deviation reports against a case base of known business behavior and prior deviations to filter out those that occur for good business reasons and alert on those that may pose a threat. - Demonstrated ability to drill down into historical patterns and supporting context information to support analysis of vessel behavior. - Installed initial system capability at operating naval site. - Participated in Trident Warrior 2008 at sea exercise.	11.050	.000	.000	
Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR) (U) The Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR) program improves battle management for complex air campaigns that employ new air platforms featuring precision sensors, weapons and communications relays. The JAGUAR system is driven by: 1) targeting information, both for sensor targets and strikes, expressed as point and area targets (i.e., search, combat air patrol); 2) rules of engagement and procedural constraints, such as airspace restrictions; and 3) availability of platforms, weapons, sensors, and communications equipment. From this information, JAGUAR produces ingress routes, flight schedules and patrol zones, while assuring airspace and electronic deconfliction. There is a	8.531	1.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Memorandum of Understanding in place with the U.S. Air Force and technology demonstration is planned to occur in late FY 2009. *FY 2008 Accomplishments:* - Developed a large-scale integration algorithm to assemble plan fragments into a synchronized operational plan. - Built optimization tools to tailor routes, schedule events, and deconflict airspace. - Tested software at the Air Force Distributed Mission Operations Center. - Modified software so it adheres to the Air Force Service-Oriented-Architecture. - Created algorithms that enable distributed JAGUAR clients to inject plans and plan changes. *FY 2009 Plans:* - Interface JAGUAR with existing Air Force databases and information systems.				
Urban Commander (U) The Urban Commander program develops automated tools to help ground commanders construct detailed, realistic operational plans, particularly in nontraditional and urban environments. Partial plans are represented in hierarchical task networks and visualized through synchronization matrices, icon overlays, or tactical sketch animations. Commanders and staff modify, refine, and extend a plan through voice, sketching, and semi-structured input. The system links fragments constructed at different sites, transfers information among related parts, and discovers and recommends solutions for inconsistencies. The system continuously compiles a set of plan cases and employs analogical matching to propose extensions to current plans suggested by past experience. Plan elements are communicated through an integrated set of protocols from the unit commander down to dismount commanders equipped with advanced displays and sensors. Finally, the program continuously assesses progress against the operational plan and alerts users to significant deviations. (U) The Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS) effort develops, integrates, and demonstrates an advanced night vision visualization system. Prototype systems are being built. The system consists of a multispectral sensor suite with a high-resolution display and a high performance	4.500	1.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
vision processor, along with a power supply and radio. The prototypes will 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 2008 Accomplishments:* - Assembled and tested prototype sensor subsystems. - Fabricated the MANTIS high-speed vision processor. *FY 2009 Plans:* - Complete test and integration of the MANTIS vision processor. - Fabricate and test prototypes. - Transition MANTIS prototypes to the U.S. Army (PEO Soldier).				
Predictive Battlespace Awareness (U) The Predictive Battlespace Awareness program developed tools to interactively draw upon a distributed network of human experts, allowing them to collaboratively anticipate an opponent's future actions. The program has enabled commanders to pre-position sensors, weapons, and information to counter the opponent's actions. The program developed model and knowledge-based techniques to predict areas of operation and tactical objectives. The technology supports the modeling of courses of action ranging over time horizons from hours to days. Program techniques permit "on-the-fly" tailoring of models and contextual knowledge, and leverage knowledge of sensor effectiveness, mobility factors, tactical templates, and target characteristics. The tools anticipate enemy operations in time to thwart them with effects-based targeting, enabling use of sensors and other resources in proactive modes. The program has significantly enhanced today's mostly manual, slow planning, and analysis processes.	3.000	.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Downselected algorithms for match-making, negotiation, monitoring and assimilation. - Defined system architecture. - Integrated selected technologies and conduct collaboration demonstrations.				
Tactical Group Decision Analysis Support System (U) The Tactical Group Decision Analysis Support System program developed distributed group decision analysis and network management tools. These tools increase the tempo of the tactical commander's observe-orient-decide-act loop, the quality of decisions, the contribution of data point input across the organization, and the necessary communications capabilities needed to support this decision structure. The tools apply to crisis management situations for tactical commanders and could be transitioned to existing emergency response command and control systems as well as emerging tactical command and control systems. The technologies developed under this program are transitioning to the U.S. Army. *FY 2008 Accomplishments:* - Performed scaling and laboratory-based experimentation.	2.000	.000	.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 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
CCC-02: INFORMATION INTEGRATION SYSTEMS	95.411	139.966	91.301						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 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Optical & RF Combined Link Experiment (ORCLE)	33.479	53.067	31.496	

(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.

FY 2008 Accomplishments:
- Planned range and flight demonstrations of air-to-air-to-ground hybrid FSO/RF links with high availability and gigabit data flows.
- Designed and engineered a prototype hybrid FSO/RF high-capacity network system.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Investigated the optical channel obscuration mitigation using ultra-short pulse lasers and partially coherent beams. - Began activities for airborne and ground experiments that will operate in direct interface to the Global Information Grid (GIG) and the tactical network gateway. *FY 2009 Plans:* - Construct and field test a brassboard system incorporating the FSO/RF components and dynamic network communication and interface system. - Perform range and flight demonstrations of hybrid FSO/RF links in operational representative environment. - Integrate and test the ORCLE terminals to verify performance and readiness for field experiments and demonstrations. - Develop, design, and build hardware and software of a prototype system for integration into military air and ground platforms. - Coordinate field demonstrations of ORCA networking that supports multiple airborne platforms, a ground node with direct interface to the GIG, and a ground node with an interface to a tactical gateway supporting Internet Protocol (IP)-addressable nodes. *FY 2010 Plans:* - Demonstrate high availability and gigabit data flow network performance with air-to-air-to-ground using multiple FSO/RF nodes in military aircraft and locations. - Demonstrate network instantiation and user interfaces to command and control at multiple levels. - Commence transition of the technology to military utility.				
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	7.205	7.625	1.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 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 Army and Marines. *FY 2008 Accomplishments:* - Demonstrated proof of concept of the distributed in-network caching and indexing services in DTN system. - Demonstrated proof of concept of the information binding on demand from a network cache in DTN system. - Demonstrated policy cognitive operation choosing best delivery options. - Integrated DTN into U.S. Marine Corps (USMC) Control On-the-Move Network Digital Over-the-Horizon Relay (USMC CONDOR) systems. *FY 2009 Plans:* - Integrate DTN into USMC military tactics, techniques, and procedures. - Deploy prototype DTN system 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 re-radiation of the correlated noise. Combining and tailoring noise correlating interferometry and retro-	1.530	2.787	1.265	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
directive antenna arrays into 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 2008 Accomplishments:* - Developed and implemented Doppler filters and tracking algorithms. - Demonstrated 3-dimensional tracking (range, azimuth, and elevation) of small caliber bullets, and Rocket Propelled Grenades (RPGs), and mortars during range live-fire experiments. - Designed and demonstrated ultra-fast radar using retro-directive antenna arrays that show a significant reduction in probability-of-intercept compared to traditional search radars based on coherent transmitters. - Initiated production manufacturability study. *FY 2009 Plans:* - Conduct cost trade study and determine system design limitations to finalize RUFAS design capabilities. - Initiate limited full-scale prototype production to support U.S. Army and U.S. Marine Corps (USMC) platform integration requirement and field evaluations. *FY 2010 Plans:* - Develop and conduct field experiments in support of USMC initial end-user field evaluations. - Complete transition to Army and/or Marines.				
Network Enabled by WDM-Highly Integrated Photonics (NEW-HIP)* *Formerly Fiber-Optical Network for Aerospace Platforms. (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	2.500	5.845	5.100	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 to the Services. *FY 2008 Accomplishments:* - Developed the target performance specification for NEW-HIP circuits to satisfy the generalized avionic networking requirements. - Conducted a successful proof-of-concept demonstration of high fidelity wideband analog signal transmission for the AN/ALQ-217 Electronic Support Measures (ESM) system using a WDM optical link in place of expensive precisely tuned coaxial copper cables. *FY 2009 Plans:* - Develop the architecture of the avionics optical network that satisfies the aforementioned requirements. - Develop the target performance specification for NEW-HIP circuits to satisfy the environmental requirements of the Joint Strike Fighter (JSF) program. - Design and prototype the following key optoelectronic components: tunable digital and analog transmitters, tunable digital and analog receivers, multi-channel digital and analog receivers and passive wavelength broadcasting and routing components with focus on digital performance metrics.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Complete the development and prototyping of the key optoelectronic components, adding analog signal capabilities. - Conduct end-to-end performance testing of the digital and analog networking systems.				
Military Networking Protocol (MNP)* *Formerly Next Generation Routing and Addressing. (U) The Military Networking Protocol (MNP) program seeks to develop networks with full military organizational unit attribution. Current network routing methodologies use internet protocol (IP) address numbers that are distributed in no defined pattern or methodology. As a result, current routing systems spend large amounts of time and computing power updating and maintaining tables that "point" to where different IP addresses are located geographically. The MNP program will resolve this issue with network addressing schemes that will reduce the load on routers as well as greatly simplify router configuration. By clearly identifying network traffic, MNP allows the network infrastructure to provide prioritization levels, reallocate bandwidth between different users or different military units, and automatically make quality of service decisions. MNP 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 Services. *FY 2008 Accomplishments:* - Investigated transition opportunities for new network addressing schemes and completed trade study on the impacts on state of the art technology. - Completed military utility analysis to establish program stretch goals. *FY 2009 Plans:* - Develop machine naming schema for data packets that are geographically based and that allow for fine grained control of precedence and improved quality of service capabilities.	1.250	4.550	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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. *FY 2010 Plans:* - Develop changes to Domain Naming Server (DNS) functions to accommodate the forwarding of services to mobile users. - Conduct demonstrations in operationally relevant environments.				
Scalable MMW Architectures for Reconfigurable Transceivers (SMART) (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. (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	8.200	10.540	14.026	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

the algorithm libraries and an 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. Furthermore, the technology will enable computational scaling to extend beyond anticipated limitations described by Moore's Law (the number of transitions on integrated circuits has doubled every year since the integrated circuit was invented). As a result 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 2008 Accomplishments:

Scalable Millimeter-wave Architectures for Reconfigurable Transceivers (SMART)

- Achieved an integrated, sixteen element (4x4) transmit (only) millimeter-wave AESA with output power greater than 5W/cm^2 and thickness less than 10mm.
- Demonstrated in an anechoic chamber the ability to direct the beam.
- Initiated development of prototype receiver components.

Analog Logic

- Developed analog logic designs and prototypes of signal processing components.
- Established analog logic hardware description library (HDL) of basic arithmetic operators.

FY 2009 Plans:

Scalable Millimeter-wave Architectures for Reconfigurable Transceivers (SMART)

- Incorporate receive capability into the AESA while maintaining the thin dimension.
- Demonstrate high isolation between transmit and receive functions.
- Conduct evaluations and demonstrations of prototype components.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Initiate development of design automation algorithms and tools. Analog Logic - Demonstrate initial analog logic signal processing prototypes. - Develop integrated analog logic circuitry for insertion into prototype radio receiver. - Design concepts and tools for integrated design flow of analog logic circuitry. *FY 2010 Plans:* Scalable Millimeter-wave Architectures for Reconfigurable Transceivers (SMART) - 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. Analog Logic - Demonstrate end-to-end capability of a receiver prototype using integrated analog logic components. - Develop and demonstrate an initial capability for automated design and synthesis of analog logic circuitry using the HDL. - Produce designs for ultra high-speed analog logic components. - Establish technology transition planning for use 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	15.739	22.958	24.414	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
develop robust networking architecture(s) and network technologies/processes that will exploit high-density node configurations. This program will culminate in a large-scale network demonstration using the multi-channel nodes. The results of the initial WNaN technology are planned for transition to the Army. *FY 2008 Accomplishments:* - Designed and built a handheld multi-channel WNaN radio that utilizes high volume, low cost Commercial off-the-shelf (COTS) radio frequency integrated circuits (RFIC), narrowband tuning filters and dual-core Digital Signal Processor (DSP) baseband processing. - Developed, integrated, and tested low risk and enhanced network technologies that exploited diverse paths and frequencies to support the network formation. - Produced prototype WNaN radios and integrated the low risk network technology for initial test and experimentation. *FY 2009 Plans:* - Conduct demonstration of ten prototype WNaN radios with low risk networking technology to include Combat Net Radio through packetized voice, simple IP services through Ethernet connection, and Position Location Information (PLI). - Conduct demonstration of forty prototype WNaN radios with first enhanced networking technology to include Disruption Tolerant Networking (DTN) and spectrum policy reasoning. - Develop, integrate, and test of the second enhanced network technologies that exploit diverse paths and frequencies to support network scalability and network formation of tens of thousands of operational nodes. - Demonstrate a communication system where the network layers can mitigate shortfalls in the radio physical layer. - Develop 100 advanced prototype WNaN radios that matches production form factor. - Develop gateway capabilities for interoperability between networks. - Initiate wireless mobile ad-hoc network (MANET) capability among gateways.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Conduct test and demonstration of 100 advanced prototype WNaN radios with the second enhanced network technologies. - Develop, integrate, and test 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. - Build and test 500-1000 pre-production WNaN radios. - Integrate final version of advanced full function network technologies into the WNaN pre-production prototype radio.				
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. Marines Corps in FY 2013. *FY 2008 Accomplishments:* - Conducted preliminary test and analysis of Bionic Ear Sensor. *FY 2009 Plans:* - Develop a system architecture to exploit network of low-power micro-sensor devices. - Conduct system design trades of power vs. performance sensitivity and accuracy. - Develop algorithms for acoustic micro-sensor network exploitation for threat detection.	1.500	2.950	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Design a brassboard system for field environments. - Build prototype systems for operational evaluation.				
Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) (U) The Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) project 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 (Joint Tactical Radio System (JTRS) cluster 1 size PC card) system. The MNM technology is planned for transition to the Army in FY 2011. *FY 2008 Accomplishments:* - Designed, built, tested, and demonstrated a multi-channel MNM radio that utilizes high volume, low cost COTS RF circuits, narrowband tuning filters and Digital Signal Processor (DSP) baseband processing. - Demonstrated 120 Mbps throughput in laboratory testing for multiple communications modes. - Designed, tested and demonstrated ability of MNM technology to perform in a narrowband interference/ jamming environment using MIMO spatial nulling approaches. - Developed, integrated, and tested low risk network technologies that exploit diverse paths and frequencies to support network scalability and network formation. *FY 2009 Plans:* - Continue development, integration, and test of high risk enhanced network technologies that exploit diverse paths and frequencies to support network scalability and network formation to support thousands of operational nodes. - Continue development, integration, testing and demonstration of MNM wideband interference mitigation technology.	1.500	3.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2010 Plans: - Demonstrate a communication system where the network layer can mitigate shortfalls in the physical layer in a live eight node demonstration. - Design, build, test, and demonstrate handheld/body wearable multi-channel MNM radio that utilizes high volume, low cost COTS RF circuits, narrowband tuning filters and dual-core DSP baseband processing.				
Mobile Ad Hoc Interoperability Networking GATEway (MAINGATE) (U) Building upon gateway technology developed under the WNaN and Future Combat Systems (FCS) Communications programs, 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 to the Army and Marine Corps with a focus on Special Operations Forces. *FY 2008 Accomplishments:* - Initiated development of an initial gateway capability for interoperability between selected legacy networks. - Initiated development of an initiation wireless MANET capability to create an adaptive IP backbone network among gateways.	7.000	15.600	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Complete development and demonstrate the initial, interoperable gateway capability. - Complete development of an initiation wireless MANET capability and demonstrate an adaptive IP backbone network among gateways. - Conduct initial evaluation of gateway and MANET performance in fielded environment. *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).				
Radio Deception Networks (U) This program will develop software and prototype hardware to enable U.S. forces to easily conduct radio deception operations. For example, the system will make it appear that U.S. forces are not where they appear to be electronically, and vice versa. The radio frequency (RF) footprint for U.S. ground forces has dramatically increased with the proliferation of radios, blue force trackers, GPS, etc. A moderately sophisticated adversary can easily gain insight into our intent by monitoring our forces' RF spectrum usage. This program's objectives will include electronically portraying a mechanized infantry battalion, both stationary and moving; and portraying the same type of unit leaving an area while it actually remains in place. Additionally, there will be metrics that address the number of people required to organize the electronic deception operations. The program is of immediate and long-term use to the U.S. ground forces. This program is planned for transition to the U.S. Army and U.S. Marine Corps. *FY 2010 Plans:* - Conduct a study to identify techniques and methods to steer directional signals using phased array antennas. - Develop algorithms, techniques, and control programs to enable RF signature deception. - Conduct breadboard testing of software solutions.	.000	.000	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Polarized Rotation Modulation (PZRM) Communications (U) The goal of the Polarized Rotation Modulation (PZRM) Communications program is 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 will investigate 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. Polarization modulation introduces an additional dimension. A radio with four polarization possibilities would transmit four times the information with all other aspects of the waveform held constant. OSSO enables multiple orthogonal signals to overlay one another in the same radio bandwidth thereby increasing spectral efficiency. Use of the antenna as part of the information processing architecture of a radio has not been previously performed. This technology has the potential to increase the capacity of existing radio channels without increasing spectrum or modem complexity. The program demonstrated as an enhancement to an otherwise state-of-the-art communications system. *FY 2008 Accomplishments:* - Completed first phase of initial research. *FY 2009 Plans:* - Complete final assessment of technology.	1.398	1.000	.000	
Next Generation (XG) (U) The Next Generation (XG) program goals are to develop 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 approach is to develop the theoretical underpinnings for dynamic access to the spectrum, the	1.600	1.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
technologies and subsystems that enable dynamic access, and the system prototypes to demonstrate applicability to legacy and future DoD radio frequency emitters. The program is investigating 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 goals are to develop, integrate, and evaluate the technology to enable equipment to automatically select spectrum and operating modes to both minimize disruption of existing users, and to ensure operation of U.S. systems. The result of the XG program will be to develop and demonstrate a set of standard dynamic spectrum adaptation technologies for legacy and future emitter systems for joint service utility. The XG communications technology is planned to transition to the Army for implementation in a range of current and future communication systems including the Joint Tactical Radio Systems clusters. *FY 2008 Accomplishments:* - Developed and demonstrated large-scale network organization and adaptation. - Integrated software into two military radios. - Conducted medium and large-scale military scenario demonstrations. *FY 2009 Plans:* - Complete technology transition to the Joint Tactical Radio System and current and future communication systems.				
Advanced Speech Encoding (ASE) (U) The Advanced Speech Encoding (ASE) program will achieve 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 will significantly decrease the probability of detection of transmitted signals and will also decrease the required transmit energy, thereby increasing battery lifetime. The program will pursue two novel approaches toward achieving its goal. One approach builds upon multiple noise-immune sensors that have been combined with traditional coding algorithms to achieve significant improvements in intelligibility and quality in harsh noisy environments. This approach will be extended to nontraditional ultra-low-bit-rate coding algorithms. An alternative approach will explore communication without acoustic information achieved by extracting laryngeal and sublingual muscle signals that are	3.992	3.995	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
produced when a person generates sub-vocal speech. This approach will yield a revolutionary capability in situations where stealth is of the utmost importance, or in situations where acoustic signals cannot be used, such as under water. The ASE technology is planned for transition to the Special Operations Command and the Communications and Electronics Command of the U.S. Army after a prototype demonstration scheduled for FY 2009. *FY 2008 Accomplishments:* - Developed a prototype real-time ultra-low-bit-rate communication system integrating the ASE VOCODER technology and a military radio. - Developed techniques to capture and enhance sub-vocal signals to enable stealth communication among warfighter teams. - Explored the nature of sub-vocalic signals (physiological source, speaker dependence, and robustness) and the information content of the signals. *FY 2009 Plans:* - Demonstrate a robust sub-vocalic silent-speech communications system. - Demonstrate the ultra-low-bit-rate communication system in the field. - Transition ASE encoding and decoding device and Government standards to DISA. - Conduct user demonstration of sub-vocalic prototypes.				
Conflict Modeling, Planning, and Outcomes Experimentation (COMPOEX) (U) The Conflict Modeling, Planning, and Outcomes Experimentation (COMPOEX) research effort is developing technologies that will 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 planned to transition to the U.S. Pacific Command (PACOM), which will continue to assist development of more	3.229	1.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
comprehensive capabilities transitioning incrementally by FY 2009. Technologies will also transition to Office of the Secretary of Defense Program Analysis and Evaluation (OSD PA&E). *FY 2008 Accomplishments:* - Developed and demonstrated technologies to support leaders and staffs in authoring courses of action and campaign plans. - Continued on going operational experiment with PACOM using COMPOEX to assist in initial planning. - The Office of the Secretary of Defense Program Analysis and Evaluation (OSD PA&E) used COMPOEX models and tools to support plan evaluation. *FY 2009 Plans:* - Complete final PACOM demonstration. - Complete the transition to OSD PA&E as one of their analytical tools.				
DARPA Interference Multiple Access (DIMA) Communications (U) The DARPA Interference Multiple Access (DIMA) Communications program will develop a networked radio system that supports voice, video and data. The goal of this program is 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 will initially develop 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 will develop and demonstrate 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 planned for transition to the services. *FY 2008 Accomplishments:* - Completed development of multi-user Parameter Estimation (PE).	5.289	4.049	.000	

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APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603760E COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS	CCC-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Completed development of DIMA Infrastructure Free Waveform/Media Access Control (MAC). - Demonstrated real-time DIMA on a COTS platform. *FY 2009 Plans:* - Reduce complexity of DIMA system. - Develop and demonstrate real-time DIMA in a mobile ad hoc network using a radio handheld platform. - Test the network in scenarios relevant to tactical users. - Transition of DIMA program.				

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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0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603760E COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS	CCC-CLS

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CCC-CLS: CLASSIFIED	82.230	146.220	140.545						Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds Classified DARPA Programs. Details of this submission are classified.

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Classified DARPA Program This project funds Classified DARPA Programs. Details of this submission are classified. *FY 2008 Accomplishments:* Details will be provided under separate cover. *FY 2009 Plans:* Details will be provided under separate cover. *FY 2010 Plans:* Details will be provided under separate cover.	82.230	146.220	140.545	

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, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603764E LAND WARFARE TECHNOLOGY

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	19.104	.000	.000						Continuing	Continuing
LNW-01: LAND WARFARE TECHNOLOGY	19.104	.000	.000						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Land Warfare Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. This program completed with FY 2008 funding and on-going efforts will continue in other program elements that fund technologies to support urban area operations.

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces, particularly in urban areas where both combatants and civilians are present. The Rapid Strike Force Technology project developed technologies that serve as force multipliers, enabling safe and effective operations in hostile environments.

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	19.642	.000	.000	
Current BES/President's Budget	19.104	.000	.000	
Total Adjustments	-.538	.000	.000	
Congressional Program Reductions	.000	.000		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	.000	.000		
SBIR/STTR Transfer	-.538	.000		

Change Summary Explanation

FY 2008
Decrease reflects the SBIR/STTR transfer.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**		**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603764E LAND WARFARE TECHNOLOGY	**PROJECT NUMBER** LNW-01

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
LNW-01: LAND WARFARE TECHNOLOGY	19.104	.000	.000						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) To support urban area operations, this project developed technologies that serve as force multipliers, enabling safe and effective operations in hostile environments.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Multi-Modal Missile (U) The Multi-Modal Missile program is exploring the development of an integrated, networked man-portable weapon system capable of performing surface-to-surface, and surface-to-air missions with an emphasis on extreme precision. Beginning in FY 2009, this program will be funded in PE 0603286E, Project AIR-01. *FY 2008 Accomplishments:* - Continued initial system design analysis and trade off studies.	3.500	.000	.000	
Non-Lethal Alternatives for Urban Operations (U) The Non-Lethal Alternatives for Urban Operations effort explored system concepts and enabled technologies for non-lethal weapons in challenging urban and semi-urban environments. *FY 2008 Accomplishments:* - Conducted less-than-lethal technology maturation efforts to address and reduce system risk. - Researched and developed prototype chemical system that reversibly denies adversary mobility (people and vehicles) by modifying ground traction, with simultaneous retention of friendly force mobility. - Performed laboratory and limited field tests of mobility control systems.	4.346	.000	.000	
Concealed Weapons Detection	3.500	.000	.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification				DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603764E LAND WARFARE TECHNOLOGY			**PROJECT NUMBER** LNW-01

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
(U) The Concealed Weapons Detection program explored various phenomenologies for concealed weapons detection. *FY 2008 Accomplishments:* - Conducted conceptual verification to determine qualitative performance achievable of stand-off imaging detection. - Developed candidate conceptual designs meeting objective system performance.				
Asymmetric Materials for the Urban Battlespace (U) The Asymmetric Materials for the Urban Battlespace program investigated a novel class of materials that, either by themselves or as part of a system, provided asymmetric capabilities in visible signatures, ballistic/fragment/blast protection, and personnel transport. *FY 2008 Accomplishments:* - Developed and integrated material components and architectures for laboratory testing.	4.874	.000	.000	
Deep Speak (U) The Deep Speak program developed new networking, coding, and waveform techniques that enable communications signals to penetrate the surrounding buildings and underground facilities. This will maintain the warfighters' links to each other and the global network, magnifying our striking power. (U) Predictive networking techniques that use current position and velocity information to predict future network topologies will reduce the number of broken links by 98%. The program is planned to transition to the Army. *FY 2008 Accomplishments:* - Developed predictive network techniques and demonstrated (through simulation) a significant reduction in the number of broken links in an urban networking environment. - Demonstrated predictive networking, multi-layer waveforms and synthetic speech encoding technologies in typical urban environments.	2.884	.000	.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603764E LAND WARFARE TECHNOLOGY	**PROJECT NUMBER** LNW-01

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, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603765E CLASSIFIED DARPA PROGRAMS

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	186.582	196.164	186.526						Continuing	Continuing
CLP-01: CLASSIFIED DARPA PROGRAMS	186.582	196.164	186.526						Continuing	Continuing

A. Mission Description and Budget Item Justification

This program element funds Classified DARPA programs. Details of this submission are classified.

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	186.992	196.697	162.551	
Current BES/President's Budget	186.582	196.164	186.526	
Total Adjustments	-.410	-.533	23.975	
Congressional Program Reductions	-10.000	-.533		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	9.590	.000		
SBIR/STTR Transfer	.000	.000		
TotalOtherAdjustments			23.975	

Change Summary Explanation

FY 2008
Decrease reflects the Omnibus and AFRICOM reprogrammings and below threshold reprogrammings.

FY 2009
Decrease reflects a reduction for Section 8101 Economic Assumptions.

FY 2010
Increases addressed under separate cover.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603765E CLASSIFIED DARPA PROGRAMS	CLP-01

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CLP-01: CLASSIFIED DARPA PROGRAMS	186.582	196.164	186.526						Continuing	Continuing

A. Mission Description and Budget Item Justification

This program element funds Classified DARPA Programs. Details of this submission are classified.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Classified DARPA Programs	186.582	196.164	186.526	

FY 2008 Accomplishments:
Details will be provided under separate cover.

FY 2009 Plans:
Details will be provided under separate cover.

FY 2010 Plans:
Details will be provided under separate cover.

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, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	132.962	154.015	135.941						Continuing	Continuing
NET-01: JOINT WARFARE SYSTEMS	55.056	44.003	40.954						Continuing	Continuing
NET-02: MARITIME SYSTEMS	25.066	30.053	28.757						Continuing	Continuing
NET-CLS: CLASSIFIED	52.840	79.959	66.230						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, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	150.677	156.733	220.952	
Current BES/President's Budget	132.962	154.015	135.941	
Total Adjustments	-17.715	-2.718	-85.011	
Congressional Program Reductions	.000	-2.718		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	-13.590	.000		
SBIR/STTR Transfer	-4.125	.000		
TotalOtherAdjustments			-85.011	

Change Summary Explanation

FY 2008
Decrease reflects the OMNIBUS and below threshold reprogrammings, and the SBIR/STTR transfer.

FY 2009
Decrease reflects the reductions for Section 8101 Economic Assumptions and reduction to proposed new starts.

FY 2010
Decrease reflects completion of Joint Warfare Systems programs, rephasing of the Tango Bravo quarter-scale submarine prototype, and repricing of other Maritime and Classified programs.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER NET-01

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
NET-01: JOINT WARFARE SYSTEMS	55.056	44.003	40.954						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 2008	FY 2009	FY 2010	FY 2011
Geospatial Exploitation (GEO)* *Formerly Federated Object-level eXploitation (FOX). (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 objects, addresses, names, and functions of natural and human-made structures. These algorithms will be scaled to operate on data streams including	10.062	4.000	4.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification			DATE: May 2009	
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 NUMBER NET-01
B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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). • The Urban Reasoning and Geospatial Exploitation Technology (URGENT) program (formerly Auto Metadata Extractions) will develop 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 Exploitation Language Technology for GeoINT program will build a system to extract and linguistically confirm terms and labels of geographic significance from graphical, textual and audio sources. The program will develop the technology to associate and verify the extracted information against features extracted from imagery. Both extraction and association will be performed against and across multiple languages. A major effort will be made to develop necessary database and query technology to support a wide range of GeoINT specific concepts, e.g., feature classes, complex distance calculations, and boundaries. • The Geospatial Representation Integrated Dataspace (GRID) program (formerly All Things Repository) will develop 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.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER NET-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: Urban Reasoning and Geospatial Exploitation Technology (URGENT) - Demonstrated automated object recognition capability on fused EO and LIDAR data from aerial and terrestrial urban sources. - Evaluated performance of automated object recognition in comparison with the performance of human geospatial analysts. Exploitation Language Technology for GeoINT - Performed preliminary design review of the GeoINT prototype. Geospatial Representation Integrated Dataspace (GRID) - Developed a new method to represent 3-D data that reduces the geospatial error of each source image when registered with a LIDAR foundation and leads to very high compression ratios in data storage without impacting a test application. *FY 2009 Plans:* Urban Reasoning and Geospatial Exploitation Technology (URGENT) - Demonstrate automated object recognition capability on fused EO and LIDAR data from aerial and terrestrial urban sources. - Evaluate speed and accuracy of performance of automated object recognition in comparison with the performance of human geospatial analysts. - Develop capability for rapid retraining on one or more new geospatial areas and object classes. Exploitation Language Technology for GeoINT - Demonstrate dynamic extraction of urban geospatial information from available documents. Geospatial Representation Integrated Dataspace (GRID) - Demonstrate 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. - Develop ability to detect changes at the object level in multi-modal geospatial data.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification				DATE: May 2009
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 NUMBER NET-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Evaluate efficiency of geospatial data encoding and change detection with comparison to geospatial data derived from national assets. *FY 2010 Plans:* Urban Reasoning and Geospatial Exploitation Technology (URGENT) - Transition selected object recognition technology to a military geospatial analysis environment. - Develop methods for automated geospatial reasoning over the shapes, locations, and classifications of objects in the urban terrain. - Evaluate automated geospatial reasoning in urban mission planning in comparison with the performance of human mission planners. Geospatial Representation Integrated Dataspace (GRID) - Demonstrate the volumetric encoding of non-optical (e.g., SAR) data with optical data. - Increase the compression ratio of volumetric data compared to raw geospatial source data. - Develop the ability to plan paths and analyze road network trafficability through complex urban terrain using fused geospatial data. - Develop the ability to propagate changes to the dataspace throughout a distributed system.				
Network Command (U) Network Command 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	6.000	3.000	2.500	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification			DATE: May 2009	
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 NUMBER NET-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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, 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 2008 Accomplishments:* Network-Centric Situation Assessment - Evaluated technologies using real-world data. Joint Mission Rehearsal - Evaluated technologies for insertion of avatars into a Helmet Mounted Display. *FY 2009 Plans:* Network-Centric Situation Assessment - Complete system design and analysis.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification			DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Joint Mission Rehearsal - Evaluate simulation technology for use in Army/Marine tactical scenarios. - Evaluate 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. - Demonstrate in a simulated urban training environment with presentation of synthetic opposition forces (OPFOR).				
Mobile Intelligent Sensors (MIS)* *Previously part of Precision Urban Combat Systems. (U) The Mobile Intelligent Sensors (MIS) program (formerly Smart Dust Sensor Networks Applied to Urban Area Operations and Exploiting Vibrations to Monitor Activities in Building) and the Remote Detection of Suspicious Vehicles (RDSV) program are developing advanced sensor, exploitation, networking, and battle management capabilities for joint dismounted forces. 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 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.	6.000	2.000	2.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: Mobile Intelligent Sensors (MIS) - Identified/prioritized critical information requirements from networked, mobile intelligent sensors in an urban environment to support small tactical units and methods for information fusion/presentation. - Evaluated candidate sensor technologies and algorithms. Remote Detection of Suspicious Vehicles (RDSV) - Conducted three successful realistic military field evaluations, including a harsh desert setting. - Successfully detected human footsteps and vehicles in the desert environment. - Showed extended range capability in urban and rural environments. - Demonstrated successful operation in environments with high RF interference. - Initiated transition experiment planning with military services. *FY 2009 Plans:* Mobile Intelligent Sensors (MIS) - Create system definition, concept of operations, and operational scenarios. - Develop payload size, weight, and power requirements (SWAP) and assess the feasibility of alternative approaches. - Define signal processing requirements and identify algorithmic approaches. - Develop technologies to separate targets from background. - Develop and demonstrate algorithms for accurate geolocation of targets and clutter within buildings. - Collect data for offline performance analysis. Remote Detection of Suspicious Vehicles (RDSV) - Execute transition experiments and system development of field deployable prototypes with the U.S. Army, the U.S. Marine Corps, and other Agencies. *FY 2010 Plans:* Mobile Intelligent Sensors (MIS) - Develop sensors meeting SWAP requirements.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**			**DATE:** May 2009	
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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Implement algorithms and integrate a prototype signal processor.				
Seismic/Acoustic Vibration Imaging (SAVI) (U) The Seismic/Acoustic Vibration Imaging (SAVI) program will develop the capability to locate both near-surface tunnels and landmines with active seismic and acoustic sources. These systems will employ well characterized seismic and acoustic sources to stimulate the targets of interest from a remote platform. The interaction of the near surface seismic waves with tunnels and other objects will be observed with a multi-pixel laser interferometer system and used to assess the depth and extent of the targets in the midst of natural and man-made clutter. Similarly, focused acoustic sources will be employed to remotely stimulate plastic or metal antipersonnel and antitank mines. A laser interferometer system will be used to detect the resonant characteristics of the mines to discriminate against natural sources of 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. *FY 2008 Accomplishments:* - Completed the preliminary reviews for the scalable system meeting the initial sensitivity and search rate objectives. - Initiated and demonstrated the technologies required for the laser interferometer system, including the sources and sensors, as well as the mobile seismic and directional acoustic sources. - Completed the development of operationally relevant test scenarios for scalable system demonstration. - Completed an outdoor demonstration of the acoustic landmine detection source and active seismic tunnel detection source meeting desired objectives. *FY 2009 Plans:* - Complete the development of the component technologies required by the scalable system demonstration. - Complete the development of high speed data processing capability to support realtime detection of buried landmines.	12.000	16.618	7.954	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER** NET-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiate scalable system integration for mobile detection demonstration. - Initiate the development of the scalable brassboard system for mobile operations. *FY 2010 Plans:* - Complete scalable system integration for mobile buried landmine and near surface tunnel. - Complete scalable system outdoor demonstration of acoustic landmine hunting and seismic tunnel testing. - Initiate scaled system development to improve coverage rate and standoff distance.				
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 within urban canyons, and extend the area coverage rate of airborne sensors by a factor of ten 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 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 2010. *FY 2008 Accomplishments:* - Developed component requirements for multi-path urban collection. *FY 2009 Plans:* - Collect representative field data in urban environment using COTS radar for use in system design and testing. - Initiate system hardware and software design. - Develop urban tracking algorithms exploiting urban multipath return. - Document algorithm performance against urban field data. *FY 2010 Plans:* - Demonstrate improvement in urban tracking using multipath radar.	4.000	5.185	4.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER NET-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Develop persistent wide-area surveillance architecture for large metropolitan areas.				
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-carried explosives (HCEs) at a stand-off range of up to 150 meters. While alternative technologies exist for HCE detection, they necessitate close-in sensing, are expensive and require extended processing times. Successful development of a HEDSS with detection ranges of up to 150 meters 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 2008 Accomplishments:* - Designed and developed data collection system. - Conducted extensive data collection and analysis. - Developed algorithms and assessed system performance. *FY 2009 Plans:* - Develop preliminary design of demonstration system including analysis to achieve low cost production. - Perform detailed design of demonstration prototype. *FY 2010 Plans:* - Conduct extensive field testing and performance analysis.	5.000	6.200	3.500	
Multi Dimensional Mobility Robot (MDMR) (U) The Multi Dimensional Mobility Robot (MDMR) program will investigate concepts using serpentine mobility to achieve new ground robot capabilities for search and rescue applications. The MDMR system will navigate complex urban terrain and provide the operator with real time images of its environment. Examples of the capability include: overcoming obstacles that are a significant fraction of its length,	5.000	1.000	.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 0603766E NETWORK-CENTRIC WARFARE TECHNOLOGY	**PROJECT NUMBER** NET-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
crossing slippery surfaces, ascending poles, climbing steep slopes, and optically sensing its immediate surroundings. The MDMR platform will be able to support a variety of search missions in hazardous environments such as urban rubble piles. To achieve such a degree of mobility, design concepts must address system challenges such as: on board power management; situational awareness; complex terrain navigation; and system controls. The technology is planned for transition to SOCOM. *FY 2008 Accomplishments:* - Developed smaller, more maneuverable serpentine platform. - Developed and tested tele-operation control. - Developed and tested sensors for integration onto the serpentine platform. - Performed rigorous testing to characterize system performance. *FY 2009 Plans:* - Demonstrate field capable performance.				
Network Targeting* *Formerly Effects Based Network Targeting. (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 validate the ability to achieve system performance goals and move incrementally toward an operational system. *FY 2008 Accomplishments:* - Designed tools to analyze single networks. *FY 2009 Plans:* - Perform system design. - Develop components and software for a system.	2.794	3.000	9.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification				DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Conduct performance validation via laboratory demonstrations and demonstrations in a controlled operational environment. *FY 2010 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. Soldiers in current operations carry upwards of 50lbs of equipment, and in some cases over 100lbs, for long distances and 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 and 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 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 Plans:* - Develop, analyze and assess preliminary designs to achieve a system capable of twenty miles of endurance in a twenty-four hour (unrefueled) period, carrying a 400lb payload. - Simulate gait selection, execution and transitioning. - Build subsystems that prove design validity. *FY 2010 Plans:* - Model foot placement, stability against disturbances, and self-righting. - Conduct subsystems testing and results analysis.	.000	3.000	8.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Complete critical design review and integration plan, and initiate demonstration system fabrication.				
Urban Ops Hopper (U) The Urban Ops Hopper program developed a semi-autonomous hybrid hopping/articulated wheeled robotic platform that could adapt to the urban environment in real-time and provide both surgical lethality and/or Intelligence, Surveillance, and Reconnaissance (ISR) to any point of the urban jungle while remaining lightweight, small and expendable to minimize the burden on the soldier. In general, small robots or unmanned ground vehicles (UGV) are severely limited by obstacle negotiation capability. The demonstrated hopping capability allows small UGVs to overcome obstacles 40x-60x their own size. Hopping will extend robot navigation to six degrees-of-freedom situational location and mapping. Hopping mobility can be shown to be five times more efficient than hovering for obstacles at heights less than or equal to ten meters. The proposed hopping robot would be truly multi-functional in that it will negotiate all aspects of the urban battlefield to deliver ISR and/or lethal payloads to non-line-of-sight targets with precision. The articulated wheel design allows the robot to negotiate short-range obstacles for precision placement in difficult terrain. This program is planned to transition to Special Operation Forces. *FY 2008 Accomplishments:* - Developed 3-D ISR obstacle detection, classification, and mapping tools for an unknown environment. - Demonstrated autonomous navigation in an urban environment using upgraded mechanical and sensor suite. - Developed precision hopping through restricted pathways to include windows and stairwells. - Demonstrated precision hopping using upgraded mechanical articulated wheel design. - Evaluated technologies in various Military Operations on Urban Terrain (MOUT) facilities.	4.200	.000	.000	

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, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603766E NETWORK-CENTRIC WARFARE TECHNOLOGY	NET-02

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
NET-02: MARITIME SYSTEMS	25.066	30.053	28.757						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 2008	FY 2009	FY 2010	FY 2011
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 Renewal 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. *FY 2008 Accomplishments:* - Conducted two at sea tests with integrated station keeping technologies and energy harvesting technologies.	3.463	3.250	2.000	

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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 0603766E NETWORK-CENTRIC WARFARE TECHNOLOGY	**PROJECT NUMBER** NET-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Coordinated with Navy and identified high interest payload for long endurance demonstration of energy harvesting and station keeping technologies. *FY 2009 Plans:* - Conduct design study of efficient energy capture for long endurance capability. - Incorporate additional technologies to improve energy capture. - Develop 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.				
Aluminum Combustor (U) The Aluminum Combustor program developed technologies to enable an energy-dense air-independent underwater power source to be used as a propulsion system for future naval undersea warfare systems. This program sought to optimize the design for a small aluminum combustor, silane fuel treatment process, and developed the auxiliary power system components needed to control and sustain operations. In addition to the combustor, the aluminum fuel feed subsystem, aluminum-steam separator subsystem; and closed loop control subsystem was designed, built, and integrated with a turbine in order to successfully demonstrate a power system in a laboratory environment. *FY 2008 Accomplishments:* - Optimized the fuel treatment protocol to prevent agglomeration and the formation of slag in the aluminum combustor. - Investigated novel naval applications for aluminum combustor power system.	1.359	.000	.000	
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	3.584	3.082	2.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 is 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. *FY 2008 Accomplishments:* - Demonstrated the feasibility of using an inverse circulation model to calculate the bathymetry given currents as an input. - Conducted two instrumented data collections of currents in a new environment/location and evaluated performance. *FY 2009 Plans:* - Continue development of the inverse model for extracting bathymetry from indirectly sensed currents. - Refine and tune algorithms for extracting circulation currents and bathymetry in more complex environments. *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.				
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	16.660	15.721	9.257	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603766E NETWORK-CENTRIC WARFARE TECHNOLOGY	NET-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 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) Following success of shaftless propulsion technologies demonstrated in the Tango Bravo program, DARPA and the U.S. Navy will design, build, and test 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 will be built to the minimum scale necessary to extrapolate hydrodynamics, powering, and acoustics to full-scale performance. The most cost effective technical approach to developing the demonstrator design will be considered, including the modification of existing large-scale submarines. Elements of the Tango Bravo program will begin transition to the Navy in FY 2009, with full transition anticipated at the conclusion of the Submarine Shaftless Stern Demonstration (S3D) program in FY 2013. *FY 2008 Accomplishments:* - Completed shaftless propulsion component fabrication (motor propulsor, duct, and structure) and component testing (electrical motor characteristics, motor drive and motor controller). - Completed the propulsion plant cost model to demonstrate the Shaftless Propulsion concept reduces submarine construction costs. - Completed analysis and evaluation of Shaftless Propulsion acoustic performance, including investigation of risk reduction technical solution. - Commenced concept studies to determine the feasibility of integrating the Shaftless Propulsion project design into a submarine design concept. - Completed the External Weapons Stowage and Launch project by conducting full-scale, test depth, weapons launch testing.				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Conducted full-scale external weapon submarine load/reload demonstration. - Completed Radical Ship Infrastructure Reduction project electric actuator bearing shock tests and commenced electric actuator dynamic load testing representative of maximum submarine operational loads and environmental conditions (seawater, test depth, silt). - Assessed programmatic and technical trade-offs to determine the optimum large-scale platform for S3D. - Commenced Shaftless Propulsion technical risk reduction tasks required prior to commencing S3D detailed design work. *FY 2009 Plans:* - Complete Shaftless Propulsion demonstrator assembly. - Complete Shaftless Propulsion integrated system testing (in-air, full load motor testing and Large Cavitation Channel acoustic testing). - Conclude 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. - Complete concept studies for S3D. - Complete Shaftless Propulsion technical risk reduction tasks on S3D. - Perform design studies and computational analysis to establish critical design parameters for S3D. - Prepare Request for Proposals (RFP) for S3D contract requirements. *FY 2010 Plans:* - Complete Shaftless Propulsion in-water endurance testing, thus concluding the Shaftless Propulsion project and Tango Bravo program. - Commence S3D propulsor detail design. - Commence S3D large-scale platform detail design.				
Maritime Persistent Surveillance and Awareness (MPSA)* *Formerly Sea Shield.	.000	3.000	3.000	

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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 0603766E NETWORK-CENTRIC WARFARE TECHNOLOGY	PROJECT NUMBER NET-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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. *FY 2009 Plans:* - Develop technologies and system concepts for detection, classification, localization, tracking and optimized engagement of maritime targets. - Develop techniques 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:* - Assess effectiveness of component technologies through modeling and simulation. - Implement the techniques 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. - Apply advanced human-computer interaction technology to optimize human/machine performance for the naval commander.				

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0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603766E NETWORK-CENTRIC WARFARE TECHNOLOGY	NET-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Blue Laser for Submarine Laser Communications (SLC) (U) The Blue Laser for Submarine Laser Communications (SLC) program was funded as the High Bandwidth Maritime Communications program in Budget Activity 2 (PE 0602702E) in FY 2009, but its applications focus made its funding more appropriate for Budget Activity 3. The program will develop the critical laser technology necessary to support the requirements for non-acoustic Anti-Submarine Warfare (ASW), mine detection, and submarine laser communication. 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 improve the detection depth of a non-acoustic anti-submarine warfare lidar system by a significant factor resulting in improved submarine communications. The Blue Laser technology is planned for transition to the Navy. *FY 2009 Plans:* - Design, build and test a power amplifier module to verify performance optically and thermally at high power. *FY 2010 Plans:* - Complete detailed design of flight brassboard transmitter. - Complete 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.	.000	5.000	10.000	
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. 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	.000	.000	2.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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.				

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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0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603766E NETWORK-CENTRIC WARFARE TECHNOLOGY	NET-CLS

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
NET-CLS: CLASSIFIED	52.840	79.959	66.230						Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds Classified DARPA Programs. Details of this submission are classified.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Classified DARPA Program This project funds Classified DARPA Programs. Details of this submission are classified. *FY 2008 Accomplishments:* Details will be provided under separate cover. *FY 2009 Plans:* Details will be provided under separate cover. *FY 2010 Plans:* Details will be provided under separate cover.	52.840	79.959	66.230	

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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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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	170.518	214.582	243.056						Continuing	Continuing
SEN-01: SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY	63.234	72.323	57.553						Continuing	Continuing
SEN-02: SENSORS & EXPLOITATION SYSTEMS	107.284	142.259	128.621						Continuing	Continuing
SEN-CLS: Classified	.000	.000	56.882						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 Exploitation 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 five needs: 1) integrating data from multipath sources into consistent situational assessments; 2) countering camouflage, concealment and deception of mobile ground targets; 3) providing near-real-time, semi-automatic exploitation of wide-area moderate and high-resolution imagery; 4) obtaining real-time, accurate battle damage assessment; and 5) accomplishing robust, precise identification, precision fire control tracking and engagement of ground targets.

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency **RDT&E Budget Item Justification**	**DATE:** May 2009
APPROPRIATION/BUDGET ACTIVITY 0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	**R-1 ITEM NOMENCLATURE** PE 0603767E SENSOR TECHNOLOGY

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	195.213	226.470	224.477	
Current BES/President's Budget	170.518	214.582	243.056	
Total Adjustments	-24.695	-11.888	18.579	
Congressional Program Reductions	.000	-11.888		
Congressional Rescissions	-9.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	-10.350	.000		
SBIR/STTR Transfer	-5.345	.000		
TotalOtherAdjustments			18.579	

Change Summary Explanation

FY 2008
Decrease reflects Section 8042 rescission, below threshold and OMNIBUS reprogrammings, and the SBIR/STTR transfer.

FY 2009
Decrease reflects reductions for Section 8101 Economic Assumptions and new starts.

FY 2010
Increases reflect the establishment of new project SEN-CLS to merge classified programs from the Guidance Technology Program Element, offset by cancelation of the SALTI program in Project SEN-02, and completion and anticipated transition of underground facilities efforts in project SEN-01.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**										**DATE:** May 2009
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 NUMBER** SEN-01	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
SEN-01: SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY	63.234	72.323	57.553						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 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Low-Altitude Airborne Sensor System (LAASS)	15.619	15.750	4.000	
(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 2011. *FY 2008 Accomplishments:* - Developed system requirements for LAASS gravity gradiometer payloads (sensor characteristics, platform envelope) against targets of interest. - Explored gravity gradiometry system concepts for tunnel detection.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification			DATE: May 2009	
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Commence evaluation of candidate sensor technologies for development of gravity gradiometer prototype evaluation system. - Produce system design and initiate development of gravity gradiometer prototype evaluation system. *FY 2010 Plans:* - Complete development and build gravity gradiometry sensor suite and perform major system design trades. - Optimize signal processing to detect target of interest in the areas of interest and reject clutter in geo-technically challenging environments. - Design, develop and integrate a prototype system on a tactical air vehicle.				
Cross-Border Tunnel (CBT) (U) The Cross-Border Tunnel (CBT) program is developing technologies and systems to detect small tunnels used to breach security perimeters and national borders. The program goal is 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 current focus is on a Fast-Scan CBT detection technique. This technique will develop 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 will provide rapid detection of anomalous subsurface structures consistent with voids. Additional techniques will be investigated to provide situational awareness to the warfighter for the underground environment. Technical challenges include: 1) identification of optimal detection strategies, source characteristics, and sensor geometries, 2) rejection of clutter with length scales similar to tunnels or	1.852	3.750	3.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
response from non-threat structures (utilities), and 3) technology migration to a moving platform. This program will transition to the Services in FY 2010. *FY 2008 Accomplishments:* - Performed field campaign to collect Electromagnetic (EM) signature data. - Evaluated the inversion of the EM data from the data collection campaign. - Determined the performance of CBT for use in protection of controlled areas and borders. *FY 2009 Plans:* - Identify a detection concept suited for use in protection of controlled areas and borders. - Determine the design requirements for the source characteristics and sensor/source geometry that optimizes the detection performance. *FY 2010 Plans:* - Commence the development of the Fast Scan CBT detection technique for an off board platform integration. - Complete the development of Fast Scan CBT detection technique for an off board platform integration. - Demonstrate the Fast Scan CBT detection technique. - Investigate techniques and conduct proof of concept demonstrations to provide the warfighter situational awareness for the underground environment. - Initiate underground situational awareness technology development efforts.				
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 (UGF) or perimeter-breaching tunnels. The ATAEM system illuminates the ground with 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), and demonstrate them on an appropriate airborne platform. The ATAEM program will first validate	6.409	9.136	7.271	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
the system concept for EM sources, sensor payloads, and associated signal processing through modeling and data collection against relevant underground structures. An integrated system combining active illumination, sensing, and detection processing will then be developed and demonstrated on an appropriate unattended air system. This capability is expected to transition to the U.S. Army, U.S. Marine Corps, and U.S. Special Operations Command in FY 2012. *FY 2008 Accomplishments:* - Developed low-noise electric and magnetic field sensors. - Designed and constructed vibration isolation system for the sensor suite. - Built sensor payload comprised of vibration-isolated electric and magnetic field sensors. - Conducted sensor tow pod design analysis. *FY 2009 Plans:* - Integrate sensor suite into helicopter tow pod. - Investigate and develop electromagnetic illumination sources. - Collect and analyze operationally relevant data over multiple targets of interest using helicopter tow pod. - Document performance as a function of operational parameters (illumination sources, flight parameters). - Develop system requirements for final demonstration system. *FY 2010 Plans:* - Fabricate and evaluate critical components for prototype system. - Commence fabrication of prototype system.				
Strategically Hardened Facility Defeat (U) Building upon the successes of this 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 proliferation of hard and deeply buried targets with major strategic capabilities around the world is	11.909	15.500	17.016	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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 seeks to leverage recent advances in earth-penetrating technologies for full defeat of strategically hardened facilities. This program will transition to the Defense Threat Reduction Agency (DTRA) in FY 2011. *FY 2008 Accomplishments:* - Integrated advanced penetration and energy supply technologies. - Demonstrated penetration, energy, sensing, and navigation capabilities through field trials. - Demonstrated deployment capabilities. *FY 2009 Plans:* - Develop robust, self-contained aerial deployment options that can interface with existing air platforms. - Develop packaging and integration technologies that can withstand harsh environments. - Design and initiate development of deployable system with advanced penetration and navigation capabilities. *FY 2010 Plans:* - Integrate component subsystems into deployable platform. - Commence the demonstration of system capabilities in multiple field exercises with transition partner.				
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 and shielded enclosures within buildings. 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	15.091	15.970	15.560	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
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. This program is developing techniques to inject and recover probing waveforms and unravel the complicated multipath in the return signals to enable the mapping and characterization of buildings. Other sensing modalities and component technologies are concurrently being investigated, such as acoustic, seismic, and thermal. These modalities offer the possibility of providing complementary information about the interior of large buildings as well as their associated underground areas. Transition of component pieces to the Army's Program Executive Office (PEO) Soldier and U.S. Special Operations Command will commence in FY 2011. *FY 2008 Accomplishments:* - Demonstrated ability to reconstruct building floor plans and track insurgents. - Developed radar system architectures for building imaging and insurgent localization. - Transitioned RADAR Scope, a handheld through the wall radar device, to PEO Soldier and U.S. Special Operations Command. - Initiated investigations into alternative sensing modalities. *FY 2009 Plans:* - Design and build functional prototype instrumentation radar system. - Perform experiments on full-scale buildings to demonstrate floor plan reconstruction and insurgent localization within structures. - Begin validating alternative sensing technologies. *FY 2010 Plans:* - Design and integrate advanced prototype demonstration system. - Commence demonstrations to show ability to determine building layout and track insurgents within furnished multi-story buildings.				
Speckle Exploitation for Enhanced Reconnaissance (SEER)	5.000	6.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(U) The Speckle Exploitation for Enhanced Reconnaissance (SEER) program will provide 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 should provide a viable signal at ranges exceeding those projected for other active laser systems. Technical achievements under other programs in this PE/Project provide the basis 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 enables 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 2008 Accomplishments:* - Demonstrated concept performance on an outdoor range. *FY 2009 Plans:* - Develop algorithms that reliably and uniquely associate target signatures with speckle patterns. - Implement algorithms using optical Micro Electro-Mechanical systems (MEMs) or other related technologies to achieve reduced size, weight and power.				
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.	3.582	2.217	2.450	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Initiated limited prototype production to support U.S. Marine Corps operational field assessment. - Completed a Memorandum of Agreement between DARPA and U.S. Marine Corps Combat Development Center for transition of the RT technology. *FY 2009 Plans:* - Evaluate deployable unit performance in U.S. Marine Corps EXERCISE Talisman Saber 2009. - Develop and conduct field experiments in support of U.S. Marine Corps initial end-user field evaluations. - Research enhancements to support system performance capabilities for military use. *FY 2010 Plans:* - Develop advanced prototypes with self-calibration and non-synchronization tag capabilities to simplify operations. - 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 current and near term near infrared (NIR) and mid-wave infrared (MWIR) based threats including man portable air defense (MANPAD), based on proactive infrared countermeasures (PIRCM). Leveraging the ongoing 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 and MWIR bands and the reactive capability of the Affordable Laser IRCM Survivability System (ALISS), 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. CLIPSS will provide U.S. aircraft the same ability to geo-locate, evade, jam, or destroy optically based air defenses and will evolve U.S. capabilities from reactive end game countermeasures to proactive capabilities that increase threat-warning times, deny launch and put electro-optical/IR air defense threats at risk. This program will demonstrate an initial integrated	.000	3.000	4.256	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
proactive and reactive IRCM pod based flight system that will address shorter range, high duty cycle threats for vulnerable low altitude platforms in the NMIR wavebands. The primary technical obstacles 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. CLIPSS technology is planned for transition to the Services in FY 2012. *FY 2009 Plans:* - Complete wide-area proactive search flight demonstration design. - Initiate subsystem fabrication for flight demonstration. - Initiate integrated proactive/reactive IRCM pod design. *FY 2010 Plans:* - Complete subsystem fabrication for flight demonstration. - Initiate wide-area proactive search demonstration integration. - Complete preliminary design review for integrated IRCM pod.				
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 correlation with the surface data will enable geo-location of the subsurface receiver. Exploitation of naturally-occurring, non-deniable 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.	.000	1.000	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
FY 2009 Plans: - Map global signal availability as function of geographic coordinates, hourly and seasonal means, and geologic overburden. - Conduct field tests to determine geolocation accuracy with varying geologic overburdens. - Revise and validate propagation models for selected geographic regions to support mission planning and performance prediction. *FY 2010 Plans:* - Develop and demonstrate through-the-earth communications for navigation (surface-to-subsurface communications) and tracking (subsurface-to-surface communications) scenarios. - Design prototype hardware for subsurface receivers and processors. - Evaluate potential for integration of global lightning receiver network data into the sferic system.				
Surveillance and Threat Neutralization in Urban Environments (U) This program investigated technologies to demonstrate the detection and defeat of threats specific to conflict and stabilization operations in the urban environment. These threats include roadside bombs, car bombs, suicide bombers, snipers, rocket propelled grenades, and mortars launched from inside urban boundaries. Detection technologies studied included detection of anomalies in vehicle dynamics, stand-off identification and localization of explosive vapors/effluents, high fidelity 3-Dimensional (3-D) mapping performed from a high altitude (>15,000 feet) airborne platform for Improvised Explosive Device (IED) detection, high fidelity 3-D surveillance performed from autogyro mortar rounds utilizing stereo vision, and precision emplacement of sensors in an urban environment. *FY 2008 Accomplishments:* - Evaluated candidate technologies for wide-area/stand-off and choke-point/portal-screening applications. - Proved feasibility in lab on sub-scale tests.	3.772	.000	.000	

C. Other Program Funding Summary ($ in Millions)

N/A

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D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
SEN-02: SENSORS & EXPLOITATION SYSTEMS	107.284	142.259	128.621						Continuing	Continuing

A. Mission Description and Budget Item Justification

(U) The Sensors and Exploitation Systems project develops and demonstrates advanced sensor and exploitation technologies to provide accurate situational awareness and precise target identification. The project is driven by five needs: (a) integrating data from multiple sources into consistent situation assessments; (b) countering camouflage, concealment and deception of mobile ground targets; (c) providing near-real-time, semi-automatic exploitation of wide-area, moderate- and high-resolution imagery; (d) obtaining real-time, accurate battle damage assessment; and (e) accomplishing robust, precise identification, precision fire control tracking and engagement of ground targets. U.S. forces and sensors are increasingly networked across service, location, domain (land, sea and air), echelon, and platform. This trend increases responsiveness, flexibility and combat effectiveness, but also increases the inherent complexity of sensor and information management. This project is creating systems that can derive high-level information from sensor data streams (from both manned and unmanned systems), produce meaningful summaries of complex dynamic situations, and scale to thousands of sources. 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 mobile missile/artillery to specific individual insurgents. This project develops and demonstrates system concepts that combine novel approaches to sensing, sensor processing, sensor fusion, and information management to enable pervasive and persistent surveillance 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 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Persistent Exploitation (U) The Persistent Exploitation program integrates a wide variety of sensors, data links, exploitation tools, correlators, and pattern analyzers into an end-to-end capability, focusing on counter-insurgency missions. These missions must be supported at all hours of the day, over large areas, and against a diverse set of targets, characteristics that no homogeneous sensor architecture can address. Persistent Exploitation ties separate hardware and software components together so that interactions among them can be defined, assessed, evaluated, and refined. It emphasizes real-time testing in realistic environments (e.g., the National Training Center (NTC)) so that subtle dependencies and interactions can be discovered.	15.522	19.178	19.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 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. *FY 2008 Accomplishments:* - Expanded investigation of close proximity sensor experiments designed to differentiate a location being used for insurgent activities from adjacent structures. - Initiated design and preliminary infrastructure development in conjunction with NTC. *FY 2009 Plans:* - Evolve close proximity experiments in the NTC environment to assess potential sensor technologies applicable to insurgent activity detection. - Continue spiral development with semi-annual exercises at the NTC and spin off mature capabilities to deployed analysis cells. - Integrate proximity sensor capabilities into the near-real-time POSSE exploitation process. - Correlate close and stand-off sensors into an integrated exploitation capability to detect insurgent networks. - Test operational capabilities at the NTC with operational analysis cells. *FY 2010 Plans:* - Continue experimentation with semi-annual exercises at the NTC and spin off mature capabilities. - Examine the feasibility of new sensor designs.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Network Centric Sensing and Engagement	8.470	7.097	7.000	

(U) The Network Centric Sensing and Engagement thrust develops technology and tools to support precise 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. Applications include advanced target detection, acquisition, tracking, and combat identification. The technology is suited to both ground-based sensors and airborne multi-ship sensor systems. Exploiting the potential of network-centric sensing requires a number of approaches. Required technology advances include: sensor-to-sensor communications, multi-sensor management, sensor system georegistration, real-time data fusion, advanced tracking, and network-centric sensor operational modes. Network technologies enabling precision electronic warfare will also be investigated. Programs in this thrust include:

• The Quint Networking Technology (QNT) is a modular, multi-band, network data link program focused on providing capabilities that close the seams between four nodes - manned aircraft, weapons, tactical unmanned air vehicles (UAVs) and air control ground units. The program designs, develops, evaluates and demonstrates robust, affordable data link technologies suitable for use by weapons, tactical UAV's, and air control units. This includes shrinking the package size of data link capabilities to the size of a cell phone. These data links enable precision strike and efficient machine-to-machine targeting against time critical and mobile targets, support combat identification of targets, disseminate tactical UAV and ground sensor data, and provide bomb impact assessment. The data links allow secure weapon handoff from the launch platform to any of several control platforms in the combat area, both air and surface. The QNT units provide two modes: a low rate bi-directional mode and a high data-rate mode capable of either continuous or a burst imagery/video transmission. Dynamic net resource management technology will scale to support hundreds of vehicles in flight. Advanced information security techniques provide secure weapon data links and controller handovers. DARPA has established a Memorandum of Agreement (MOA) with the Air Force Command and Control & Intelligence, Surveillance, and Reconnaissance Center, Navy Program Executive Officer, Strike Weapons and Unmanned Aviation, and Air Force Research Laboratory to transition the QNT technology.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
• The Tactical Level Operations Capability (T-LOC) program (formerly Expeditionary Dismount Geolocation and Exploitation System) will develop and deploy technologies to integrate temporal-spatial data from multiple sources to increase situational awareness. 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. There is particular interest in riverine operations, and within this context, sensor, delivery systems, exploitation algorithms, and information management and display technologies will be developed. T-LOC will provide the means to discover vulnerabilities in opposing forces and cues for intelligence, surveillance, and reconnaissance planning. Technologies are planned to transition to the U. S. Navy and U.S. Marine Corps. *FY 2008 Accomplishments:* Quint Networking Technology (QNT) - Built and evaluated brassboard in Stage 1 tests. *FY 2009 Plans:* Quint Networking Technology (QNT) - Cycle and test brassboard in Stage 2 tests and flight tests. - Start transition to Air Force and Navy. Tactical Level Operations Capability (T-LOC) - Evaluate the effect of combining multiple organic sensor updates on situation assessment for rapid military riverine operations. *FY 2010 Plans:* Tactical Level Operations Capability (T-LOC) - Evaluate the effect of combining multiple semi-autonomous organic sensor updates and novel display technologies on situation assessment for rapid military riverine operations.				
Pattern Analysis Technology	2.000	1.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

(U) The Pattern Analysis Technology thrust develops exploitation tools to form and analyze tracks of vehicle movement, and distinguish hostile behavior from benign civilian activities. It develops tools for movement pattern analysis, algorithms to predict target motions, and dynamic control methods for sensor tasking and observation scheduling. Programs in this thrust include:

• The Video Verification and Identification (VIVID) program developed technology to automate moving target strike operations for remotely piloted aircraft. Program products support both precision strike operations and military surveillance. VIVID enables the handoff of targets between wide area coverage intelligence, surveillance, and reconnaissance systems and local video surveillance platforms. The technology provides techniques for precision target identification in video including fingerprinting techniques and related technology to reacquire previously observed vehicles. The VIVID technology transitioned to the Air Force at the conclusion of Phase II, at the end of FY 2008.

• The Forensic Target Motion Analysis program develops and demonstrates exploitation tools to analyze Ground Moving Target Indicator (GMTI) Radar tracks of multiple targets to separate militarily-interesting target movement from nominal background traffic (e.g. civilians, coalition operations). It develops libraries of movement patterns, logic to generate hypotheses about which patterns are being observed, algorithms to correlate sensor data to those patterns, and mechanisms to quantitatively score the consistency of the data with each hypothesis. It also includes tools to provide short-term predictions of target motions, thereby supporting some forms of predictive threat analysis.

FY 2008 Accomplishments:

Video Verification and Identification (VIVID)
- Demonstrated real-time software components on tower.
- Demonstrated real-time software components in flight test.
- Started transition to the U.S. Air Force.

Forensic Target Motion Analysis
- Obtained ground-truthed, wide-area GMTI data from operational airborne sensors.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: Forensic Target Motion Analysis - Evaluate performance of motion analyses algorithms.				
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. Three programs are funded in this thrust: • The Exploitation of 3-D Data (E3D) program developed techniques for rapidly exploiting 3-D sensor data. The initial program effort consisted of three distinct processes: Target Acquisition, Target Recognition, and Modeling. The resulting software tools were integrated into operational ground stations processing 3-D sensor data. The E3D technology was transitioned to Special Operations Command (SOCOM). • The All-Source Target Characterization program develops a collection and measurement capability to characterize new targets as they emerge on the battlefield. This effort develops tools to permit rapid user interaction with imagery, sensor data, and processing results and provides real-time feedback to operators indicating key target features and other discriminates. This initiative will also develop and demonstrate 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	8.896	9.000	8.000	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

systems. Technologies are planned for transition to the Air Force Distributed Common Ground Station in FY 2011 and subsequently to the U.S. Army Future Combat System.

• The Small Unmanned Aerial Vehicle Detection System (SUDS) program, formerly Detect Unmanned Aerial Vehicle (UAV), 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 military in FY 2012 to meet both static force protection needs and tactical air defense operations.

FY 2008 Accomplishments:

Exploitation of 3-D Data (E3D)
- Conducted real time data collection for models in library.
- Transitioned E3D to SOCOM.

All-Source Target Characterization
- Developed tools to permit rapid user interaction with imagery and processing results.

Small UAV Detection System
- Generated candidate system architecture, focusing on an effective sensor suite, to detect and track small UAVs.
- Conducted flight tests to collect small UAV and clutter signatures.
- Completed post processing of acoustic data.
- Performed initial trade studies and analyses.

FY 2009 Plans:

All-Source Target Characterization

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Evaluate performance in field exercises and demonstrations. Small UAV Detection System - Develop algorithms to identify and classify targets and objects of interest. - Perform 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. - Perform data collection to determine acoustic features/signatures/characteristics. - Apply results to physics models of aircraft and propulsion systems. *FY 2010 Plans:* Small UAV Detection System - Develop and demonstrate target identification capability. - Integrate multiple sensors for target classification. - Evaluate system performance for positive identification of friend or foe.				
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 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 NetTrack program will extend capabilities for persistent tracking and targeting of moving vehicles from airborne radars. Operational GMTI radars can display the locations of thousands of movers over a	11.527	18.960	22.890	

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
wide area. Operators of these systems can focus on an individual GMTI detection and follow the vehicle down a road network until a so-called "confusion event": the vehicle reaches an intersection at the same time as other traffic; another vehicle comes close to it traveling in the same direction; the GMTI platform has to make a turn. After the confusion event the operator has no way to determine which of several local target detections is the vehicle that the operator was following. NetTrack will improve capabilities in two ways: the system will network radars together and use advanced radar techniques to gather "signatures" of vehicles. The signatures, which are collections of radar features, will be stored and passed over the radar network. The system will compare vehicle signatures taken before and after confusion events to maintain the track of the target vehicles. Extended long-term airborne radar tracking will be an important long-range, all-weather capability. It will extend the kill chain to enable vehicle engagement hours after target designation, enable behavioral analysis of vehicle movements to gauge enemy operational structure, force composition, and intentions, and provide a higher level of situational awareness at every level. Technologies are planned for transition to the Navy, Army and Air Force. • The Dual Beam Lynx program will enhance the capabilities of the Lynx radar system to track slow-moving vehicles more accurately. The program modifies a Lynx I radar to create two beams with different phase centers and uses space-time adaptive processing to detect moving targets in the main beam clutter. The goals of this program include demonstrating improvement in minimal detectable velocity, improving geolocation accuracy, and achieving a low manufacturing cost. The radar performance will be demonstrated from flight data collected from the radar flying on a UAV surrogate. Technology is planned for transition to the U.S. Air Force. • 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. This system will enable signal detection at extended ranges, detecting faint or distant signals with high gain. This program is planned for transition to the U.S. Air Force. • 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 supporting small tactical units. ATVS sensors will fly on a tactical UAV such as the Scan Eagle				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

and will provide company/battalion size forces with a dedicated airborne sensor for detecting and locating emitters. ATVS provides accurate estimates of the angle of arrival in both azimuth and elevation. 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. Most existing RF arrays used in radar, communications and Signal Intelligence systems have highly constrained digital beamforming capabilities since the element-level signals are not digitally sampled; rather, these signals are combined into a single beam or sometimes sub-array beams before digitization. This sub-optimal combining was necessary because the number of receivers, analog-to-digital converters and data rate of the system are limited by the available size, weight, and power. However, compressive sensing techniques present the opportunity to reclaim this lost performance. Technologies are planned for transition to the Navy, Army and Air Force.

FY 2008 Accomplishments:

NetTrack
- Improved capabilities for using vehicle radar signatures to associate vehicle observations.
- Demonstrated NetTrack operations in simulation.

Dual Beam Lynx
- Conducted preliminary design review.
- Developed algorithms.
- Modified Lynx radar to add dual beam capabilities.

FY 2009 Plans:

NetTrack
- Demonstrate radar signature-aided vehicle tracking and simulate the cooperative use between radar platforms of those radar features.
- Implement NetTrack capabilities in an operational airborne radar system.

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Dual Beam Lynx - Develop space time adaptive processing. - Perform flight test and data collection. Next Generation RF Antenna System - Refine electromagnetic models. - Fabricate and measure RF properties. - Measure pattern of antenna to validate predictions on gain, bandwidth and signature. *FY 2010 Plans:* NetTrack - Demonstrate NetTrack capabilities in real-time on operational networked radar platforms. 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 - 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.				
Advanced Airborne Optical Sensing	13.000	14.885	19.271	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
(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 greater numbers 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 includes: 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; 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. Technologies developed in the Advanced Airborne Optical Sensing program are planned for transition to the U.S. Army and the U.S. Air Force. 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; (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 achieve a Class IV UAV-compatible (Predator, Firescout & Warrior) configuration for installation into a Multi-spectral Targeting System (MTS) turret for transition to the U.S. Air Force at the conclusion of Phase III. The program will produce high speed, ultra sensitive photodetectors				

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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. • 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 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. The effort will improve performance of the technology, specifically using diffuse reflective targets, targets with lower contrast and reduced intensity reference beam. 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 (formerly Hyperspectral Framing) 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 2008 Accomplishments:* Standoff Precision ID in 3-D (SPI 3-D) - Completed preliminary design for integration into Multi-Spectral Targeting Systems (MTS) turret. - Demonstrated metric sensing concept using a manned airborne testbed.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: Standoff Precision ID in 3-D (SPI 3-D) - Hold critical design review and initiate fabrication of flight sensor components for turret integration. Spatially Processed Image Detection and Ranging (SPIDAR) - Perform initial outdoor demonstration against enhanced targets to show spatial heterodyne approach is able to form imagery under turbulent seeing conditions. - Perform initial assessment of the performance of the current system configurations and systems analysis of long-range, high-resolution imaging applications. - Identify the trade space for considering multi-aperture receivers and illuminators in the system designs. - Define and detail performance of underlying key component technologies (including stable, high-power laser sources, high-speed imaging focal planes and image processing analysis). - Develop conceptual system designs to achieve desired system performance. - Initiate system design for extended-range ground-based demonstration. Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND) - Complete preliminary design of infrared and color sensor package. - Develop 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 turret system. Spatially Processed Image Detection and Ranging (SPIDAR) - Fabricate ground-based demonstration for >5 sub-apertures at short range. - Complete Critical Design Review (CDR) for airborne demonstration at long range. 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 algorithm.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Wide Area Video Surveillance*	6.693	10.040	13.000	

*Previously this was part of Advanced Airborne Optical Sensing.

(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 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 (formerly known as Advanced Optical Sensing) 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. The transition period is FY2009–FY2010.

• 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

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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. *FY 2008 Accomplishments:* Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System (ARGUS-IS) - Completed preliminary and critical design review for each of the ARGUS-IS subsystems. - Developed advanced signal processing techniques for the rapid formation of optical imagery and verified that the processing performance meets all the requirements for the overall system. - Verified that the sensor and ground processing systems satisfied the design parameters. - Designed and built the telescopes and composite focal plane arrays for the gigapixel sensor. - Designed the electronics associated with the gigapixel sensor. - Validated the ground processing system's ability to command the airborne processing system, storage, and video window display. *FY 2009 Plans:* Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System (ARGUS-IS) - Complete the build of the gigapixel sensor. - Integrate sensor, airborne processor, and data link into A-160 pod. - Perform test flights utilizing a modified Blackhawk Helicopter. - Complete software development for ground processing and airborne processing systems. - Conduct flight experiments for video windows and video tracking. - Begin building a copy of the sensor and airborne processor for U.S. Air Force. *FY 2010 Plans:* Autonomous Real-time Ground Ubiquitous Surveillance – Imaging System (ARGUS-IS)				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- 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.				
Large Area Coverage Search-while-Track and Engage (LACOSTE)* *Previously this was part of Advanced Airborne Optical Sensing. (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 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.	4.407	12.150	15.460	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Developed objective system designs and demonstrated the core technologies – electronically addressable mask and computational imaging algorithms. *FY 2009 Plans:* - Complete scaled integration of core system technologies. - Develop and test 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.				
Synthetic Aperture Ladar for Tactical Imaging (SALTI) (U) The Synthetic Aperture Ladar for Tactical Imaging (SALTI) program will develop and demonstrate an airborne synthetic advanced laser radar (LADAR) capable of creating a synthetic aperture for high-resolution, three-dimensional imagery at long ranges. The technical objective of the SALTI program is to provide a proof-of-feasibility for operation at tactically relevant high altitudes and at long ground ranges. The SALTI approach combines the long-range day/night imaging afforded by conventional synthetic aperture radar techniques exploiting high power, high bandwidth laser radars. The result is 3-D imagery for target location and identification at high fidelity and potentially small size and weight. The SALTI program has produced the first-ever synthetic aperture LADAR images from aircraft. *FY 2008 Accomplishments:* - Developed lasers for higher power and higher bandwidths to support Long Range Demonstration (LRD). - Characterized propagation through the atmosphere under operational conditions to assess long range operational performance. - Generated and modified system design to support LRD.	6.689	16.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Develop high power, high bandwidth ladars for meeting SALTI requirements. - Develop mitigation techniques to counter atmospheric turbulence effects. - Develop and test acquisition, pointing and tracking subsystem for creating synthetic aperture ladar images at long range. - Review feasibility of designs to place SALTI in a pod.				
Ground Targeting Sensors (U) The Ground Targeting Sensor thrust provides sensors and signal processing systems to detect, identify, and engage close-in ground targets. Its products are installed on platforms that operate on the ground (HUMVEE, convoy elements) and near the ground (helicopters). They employ technologies that defeat or compensate for the unusual atmospheric conditions near the surface (turbulence, dust, strong propagation losses) in order to provide timely and accurate detection and classification of dismounts, small vehicles, and terrain obstacles. Programs in this thrust include: • The SandBlaster program will develop a helicopter pilot performance enhancement system for landing in degraded visual environments such as Iraq and Afghanistan dust clouds. Sandblaster addresses 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 will transition to U.S. Special Operations Command (USSOCOM), the U.S. Air Force and the U.S. Army. • 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	17.540	17.952	15.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

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. Technology developed under this program will transition to Special Operations Forces.

• 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 2008 Accomplishments:

SandBlaster

- Completed SandBlaster flight-simulator testing and evaluation.
- Completed and installed millimeter-wave radar in the JUH-60A Blackhawk helicopter.
- Completed and installed fusion engine in the JUH-60A Blackhawk helicopter.
- Completed and installed Advanced Flight Control subsystem in the JUH-60A Blackhawk helicopter.
- Completed and installed synthetic vision display in the JUH-60A Blackhawk helicopter.
- Conducted initial radar testing in the JUH-60A Blackhawk helicopter.

Super-Resolution Vision System (SRVS)

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Investigated optimal control algorithms and implementation. - Completed prototype design; fabricated brassboard system. - Conducted field experiments and testing to optimize system performance. - Conducted Probability of Identification (PID) testing and obtained 90% PID on SRVS resolved imagery. Short Wave Infrared through Fog and Clouds (SWIF) - Completed tradespace analysis of pulse propagation characteristics. *FY 2009 Plans:* SandBlaster - Complete Sandblaster system performance testing and demonstrate capabilities in the JUH-60A Blackhawk helicopter. - Transition Sandblaster technology to the services. Super-Resolution Vision System (SRVS) - Conduct demonstration and testing of prototype systems. - Modify design based on experiments and testing to support transition. Short Wave Infrared through Fog and Clouds (SWIF) - Develop imaging algorithms. - Conduct modeling and simulation to optimize system range and resolution. - Conduct experiments under various scattering and absorption conditions to characterize optical link budget. - Demonstrate imaging algorithm performance in controlled conditions. - Develop distributed active obscurant technologies. - Package and test distributed obscurant. *FY 2010 Plans:* Super-Resolution Vision System (SRVS) - Conduct conceptual studies to identify possible lens variations, including adaptive polymer lenses.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Commence fabrication and testing of soldier portable prototype. - Conduct field testing of system performance. Short Wave Infrared through Fog and Clouds (SWIF) - Distribute obscurant chamber testing and system validation.				
Soldier-borne Sensor Technology (U) The Soldier-borne Sensor Technology thrust provides sensors for improved situational awareness and effectiveness of individual soldiers. It builds small unit enemy weapon fire detection and classification tools, more precise target designation sensors, and methods for improved small arms weapon effectiveness. Programs in this thrust include: • The Crosswind Sensor System for Snipers (C-WINS) program will provide optical techniques to correct for crosswinds on ballistic objects. The C-WINS program will develop a novel weapon mounted optical correction sighting system for various rifles and machine guns. An eye safe laser and a high speed camera will record motion of eddies in the atmosphere to measure wind profile that will used to provide ballistic correction. The system will provide 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 is planned for transition to the U.S. Army and Marines. • The Laser Geospatial Referencing (LGR) system will 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 provides 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. LGR technology could dramatically reduce the time required for targeting existing firepower in the	7.930	11.997	3.500	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

form of man-portable missiles, light armor, tanks, artillery and ground attack aircraft. LGR technologies will be transitioned to the U.S. Army and Marine ground forces, and U.S. Air Force and Army.

• 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 2008 Accomplishments:

Omni-Directional Flash & Launch Detection, Positioning, Classification and Observation System (MEGA)
- Developed and demonstrated IR sensor prototype.
- Developed and demonstrated stationary omni system.
- Developed and demonstrated mobile platform omni system.

Crosswind Sensor System for Snipers (C-WINS)
- Designed and built electronics board sufficient to trigger laser at required rates, receive, store and process data (on line and offline).
- Integrated system and conducted field tests to validate the proposed concept as a function of the crosswind and scintillation index.
- Demonstrated system capability to correct crosswind effects on ballistic trajectory.

FY 2009 Plans:

Crosswind Sensor System for Snipers (C-WINS)
- Develop transition and manufacturing plans.
- Develop and build three prototype systems and integrate and test system in the lab and field.

Laser Geospatial Referencing (LGR)
- Complete initial feasibility study to determine concept of operations (CONOPS) and design requirements.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification			DATE: May 2009	
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Assess technology development required to meet objectives and developed program plan. - Initiate supporting focal plane array technology development for LGR. Sensor Tape - Demonstrate proposed sensors and communications capability in controlled laboratory experiments. - Integrate modules into a complete first generation prototype blast dosimeter. - Develop jet-printing processes required for printed sensors, printed electronics and printed memory components. - Develop printed pressure, acceleration, light and acoustic sensors. - Develop proposed sensors and communications capability in controlled laboratory experiments. *FY 2010 Plans:* Crosswind Sensor System for Snipers (C-WINS) - Implement transition and manufacturing plans. - Transition to the Army and Marine Corps. Sensor Tape - Demonstrate web-printing process for sensors, printed electronics and memory components. - Fabricate prototype sensor tapes. - Demonstrate sensor tape performance in field test.				
Precision Electronic Warfare (PreEW) (U) Precision Electronic Warfare (PreEW) 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	.000	.000	5.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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. - Perform experiments to validate clock synchronization, precision pointing, and precision jamming capabilities.				
Foliage Penetration Reconnaissance Surveillance Tracking and Engagement Radar (FORESTER) (U) The Foliage Penetration Reconnaissance Surveillance Tracking and Engagement Radar (FORESTER) program is developing 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 is now finishing up with radar field experiments conducted jointly with operational users to refine and optimize FORESTER radar performance and concepts of operation. At the conclusion of these experiments FORESTER will transition to Service partners. The FORESTER program was previously budgeted in PE 0603764E, Land Warfare Technology, Project LNW-03, Future Combat Systems which ended in FY 2007. Work is continuing in the Sensor Technology PE to complete demonstrations and program transition. *FY 2008 Accomplishments:* - Flew FORESTER antenna on A160 and demonstrated sufficient stability for radar imaging. - Flew full FORESTER on an A160 and demonstrated electromagnetic compatibility.	4.610	4.000	.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2009 Plans: - Conduct radar field experiments and then, based on the results, refine and optimize FORESTER radar performance and concepts of operation. - Transition FORESTER to the operational user.				

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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0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 3 - Advanced Technology Development (ATD)	PE 0603767E SENSOR TECHNOLOGY	SEN-CLS

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
SEN-CLS: Classified	.000	.000	56.882						Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds Classified DARPA Programs. Details of this submission are classified.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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.	.000	.000	56.882	

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, PB 2010 Defense Advanced Research Projects Agency **RDT&E Budget Item Justification**	**DATE:** May 2009
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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	114.752	107.979	37.040						Continuing	Continuing
GT-01: GUIDANCE TECHNOLOGY	35.526	32.771	17.235						Continuing	Continuing
GT-CLS: CLASSIFIED	79.226	75.208	19.805						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 specific 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.

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	124.974	110.572	80.238	
Current BES/President's Budget	114.752	107.979	37.040	
Total Adjustments	-10.222	-2.593	-43.198	
Congressional Program Reductions	.000	-2.593		
Congressional Rescissions	-3.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	-3.800	.000		
SBIR/STTR Transfer	-3.422	.000		
TotalOtherAdjustments			-43.198	

Change Summary Explanation

FY 2008

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Decrease reflects a below threshold reprogramming action, SBIR/STTR transfer, and the Section 8042 rescission.

FY 2009
Decrease reflects reductions for Section 8101 Economic Assumptions and new starts.

FY 2010
Decrease reflects completion of Guidance Technology programs and relocation of programs to the Sensor Technology Program Element.

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
GT-01: GUIDANCE TECHNOLOGY	35.526	32.771	17.235						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 2008	FY 2009	FY 2010	FY 2011
Multifunctional Electro-Optics for Defense of U.S. Aircraft (MEDUSA)	10.856	8.615	5.892	
(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. MEDUSA is a three-part technology program: 1) conduct phenomenological measurements and develop countermeasures and target classification/identification techniques; 2) develop critical component technologies such as high-power IR laser sources, advanced IR detectors, and fibers for high-power IR transmission; and 3) develop and demonstrate 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. *FY 2008 Accomplishments:* - Fabricated first fully integrated large format 128x128 Near/Mid-Wave Infrared (NMIR) focal plane arrays (FPA) integrated with a low-power, high-speed Read-Out Integrated Circuit (ROIC), demonstrating high-				

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
sensitivity and high-gain (>300) performance in an integrated FPA/ROIC compact camera cryo-cooler package. - Fabricated final Long-Wave Infrared (LWIR) ROIC prior to hybridization with FPA. *FY 2009 Plans:* - Complete testing of 128x128 NMIR FPA and initiate designs for fabrication of 256x256 arrays. - Complete fabrication of first fully integrated large format 128x128 LWIR FPA integrated with a low-power, high-speed ROIC, demonstrating high-sensitivity large format heterodyne receiver performance in an integrated FPA/ROIC compact camera cryo-cooler package. *FY 2010 Plans:* - Conduct integration and system testing. - Complete fabrication and testing of 256x256 arrays. - Conduct integrated airborne proactive Infrared Counter Measure (IRCM) demonstration.				
Robust Surface Navigation (RSN)* *Formerly Robust Surface and Sub Surface Navigation (RSN/SSN). (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, and 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 lack of penetration into buildings, and when severe multipath is a problem. 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.	5.330	5.508	4.000	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Completed concept design of RSN systems. - Conducted end-to-end performance modeling of the RSN system for stationary, walking, driving, and flying users, in urban, forested, and open environments. *FY 2009 Plans:* - Complete fabrication of RSN prototype system and conduct field test in urban environment. - Perform RSN technical risk mitigation experiments and analysis. *FY 2010 Plans:* - Conduct field test and demonstrate the functional RSN prototype in forested, jungle and open environments, and for airborne users. - Demonstrate total system readiness. - Transition RSN technology.				
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, when 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 three-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-	3.340	2.948	1.343	

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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 0603768E GUIDANCE TECHNOLOGY	PROJECT NUMBER GT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
form-fit) prototype receiver(s) and algorithms for geolocation using both beacons and SoOP. The SsN beacon technology is planned for transition to U.S. Special Operations Command. *FY 2008 Accomplishments:* - Designed prototype beacon-based SsN system, including subsystem development and testing. - Isolated and quantified the primary sources of error in the beacon antenna and identified approaches for reducing these in the Phase II design. - Initiated development of electromagnetic modeling capability to predict beacon-based system performance. - Initiated development of next generation, small form-factor beacons. *FY 2009 Plans:* - Continue design and development of prototype system with improved beacons and receivers. - Continue development of next generation, small form-factor beacon antenna design. - Develop 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. - Develop electromagnetic modeling capability to predict beacon-based system performance. - Test functional prototype beacon-based system for underground use; demonstrate system in multiple representative environments. *FY 2010 Plans:* - Complete transition of SoOP technology to U.S. Special Operations Command (SOCOM).				
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	6.000	4.000	6.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification			DATE: May 2009	
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 NUMBER GT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
will focus on developing fundamental technology components upon which future systems would be constructed. The PINS technology is planned for transition to the Navy at the conclusion of Phase III. *FY 2008 Accomplishments:* - Demonstrated single sensor integrating single axis high-performance accelerometer, gyroscope, and gravity gradiometer. - Completed open-ocean test campaign with combat swimmers demonstrating fifty meter per hour submerged navigation error. *FY 2009 Plans:* - Design and build six degree-of-freedom atom-based inertial measurement unit and multi-axis gravity gradiometer for extended laboratory testing. - Design and construct pre-production prototype for final evaluation by Marine Corps combat swimmers. *FY 2010 Plans:* - Complete laboratory testing of six degree-of-freedom atom-based inertial measurement unit and multi-axis gravity gradiometer, demonstrating less than 500 meters accumulated error after 100 hours of testing. - Transition atom interferometer-based navigation system to Navy Strategic Submarine Program Office.				
Navigation-Grade MEMS Inertial Measurement Unit (IMU) (U) The Navigation-Grade MEMS Inertial Measurement Unit (IMU) program will develop micro-scale accelerometers and gyros with navigation-grade performance that use only milli-watts of power. The program will transcend traditional single mass-spring methods for navigation sensing and will explore 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 will transition to industrial performers by 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—all of which will go into DoD systems.	10.000	11.700	.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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 NUMBER** GT-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2008 Accomplishments: - Developed levitation methods. - Developed fluid contortion sensing. *FY 2009 Plans:* - Develop micro-environmental control. - Control electronics integration.				

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, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification										DATE: May 2009
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 NUMBER GT-CLS	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
GT-CLS: CLASSIFIED	79.226	75.208	19.805						Continuing	Continuing

A. Mission Description and Budget Item Justification

This project funds Classified DARPA Programs. Details of this submission are classified.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Classified DARPA Program This project funds Classified DARPA Programs. Details of this submission are classified. *FY 2008 Accomplishments:* Details will be provided under separate cover. *FY 2009 Plans:* Details will be provided under separate cover. *FY 2010 Plans:* Details will be provided under separate cover.	79.226	75.208	19.805	

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, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	74.569	.000	.000						Continuing	Continuing
SB-01: SMALL BUSINESS INNOVATIVE RESEARCH	74.569	.000	.000						Continuing	Continuing

A. Mission Description and Budget Item Justification

In accordance with Public Law 106-554 (Small Business Reauthorization Act of 2000) 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 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	.000	.000	.000	
Current BES/President's Budget	74.569	.000	.000	
Total Adjustments	74.569	.000	.000	
Congressional Program Reductions	.000	.000		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	.000	.000		
SBIR/STTR Transfer	74.569	.000		

Change Summary Explanation

FY 2008
Increase reflects the SBIR/STTR transfer.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 6 - RDT&E Management Support	PE 0605502E SMALL BUSINESS INNOVATIVE RESEARCH	SB-01

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
SB-01: SMALL BUSINESS INNOVATIVE RESEARCH	74.569	.000	.000						Continuing	Continuing

A. Mission Description and Budget Item Justification

In accordance with Public Law 106-554 (Small Business Reauthorization Act of 2000) 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. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Small Business Innovative Research *FY 2008 Accomplishments:* The DARPA SBIR and STTR programs are being executed within OSD guidelines.	74.569	.000	.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-2, PB 2010 Defense Advanced Research Projects Agency **RDT&E Budget Item Justification**	**DATE:** May 2009
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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	.000	27.924	45.000						Continuing	Continuing
AR-02: DARPA AGENCY RELOCATION	.000	27.924	45.000						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 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	.000	28.000	45.000	
Current BES/President's Budget	.000	27.924	45.000	
Total Adjustments	.000	-.076	.000	
Congressional Program Reductions	.000	-.076		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	.000	.000		
SBIR/STTR Transfer	.000	.000		
TotalOtherAdjustments			.000	

Change Summary Explanation

FY 2009

Decrease reflects reductions for Section 8101 Economic Assumptions.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification			DATE: May 2009
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		PROJECT NUMBER AR-02

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
AR-02: DARPA AGENCY RELOCATION	.000	27.924	45.000						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. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
DARPA Agency Relocation *FY 2009 Plans:* - Support GSA contracting for commercial construction of new facility. - Implement force protection standards such as blast proofing and procure long lead items, vehicle barrier/entry control system, door and perimeter sensors, access control system and intrusion system for restricted areas. - Design tenant build out of commercial facility. *FY 2010 Plans:* - Construct tenant build out of commercial facility to include: - Unclassified office space. - Classified office space (Sensitive Compartmented Information Facilities (SCIFs) and Temporary Secure Working Areas (TSWAs)). - Conference center.	.000	27.924	45.000	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification	DATE: May 2009

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT NUMBER
0400 - Research, Development, Test & Evaluation, Defense-Wide/BA 6 - RDT&E Management Support	PE 0605897E DARPA AGENCY RELOCATION	AR-02

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Wiring closets; building security system; unclassified and classified cabling; and all associated activities to prepare the building for occupancy.				

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, PB 2010 Defense Advanced Research Projects Agency **RDT&E Budget Item Justification**										**DATE:** May 2009
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 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
Total Program Element	51.480	48.568	51.055						Continuing	Continuing
MH-01: MANAGEMENT HQ - R&D	51.480	48.568	51.055						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. During Base Realignment and Closure (BRAC) discussions, DARPA was instructed to work with the General Services Administration and Washington Headquarters Service personnel to prepare to vacate the Agency's current headquarters building at the end of its lease (2010) and relocate to a facility that meets force protection requirements. The FY 2008 budget included funds to begin design and trade studies and initial floorplan layout. A new Program Element was established for DARPA relocation expenses starting in FY 2009 (PE 0605897E).

B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	48.480	52.700	56.876	
Current BES/President's Budget	51.480	48.568	51.055	
Total Adjustments	3.000	-4.132	-5.821	
Congressional Program Reductions	.000	-4.132		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	3.000	.000		
SBIR/STTR Transfer	.000	.000		
TotalOtherAdjustments			-5.821	

Change Summary Explanation

FY 2008

Increase reflects a below threshold reprogramming action to cover increase in funding for new hires, recruitment and retention bonuses, and separation incentives.

Exhibit R-2, PB 2010 Defense Advanced Research Projects Agency RDT&E Budget Item Justification	DATE: May 2009
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

FY 2009
Decrease reflects reductions for Section 8101 Economic Assumptions and unexecutable growth.

FY 2010
Decrease reflects adjustments to salaries and benefits for revised pay raise assumptions and repricing of operational support in anticipation of the agency relocation in the timeframe 2011-2012.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification									DATE: May 2009	
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					PROJECT NUMBER MH-01	
COST ($ in Millions)	**FY 2008 Actual**	**FY 2009 Estimate**	**FY 2010 Estimate**	**FY 2011 Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
MH-01: MANAGEMENT HQ - R&D	51.480	48.568	51.055						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. During Base Realignment and Closure (BRAC) discussions, DARPA was instructed to work with the General Services Administration and Washington Headquarters Service personnel to prepare to vacate the Agency's current headquarters building at the end of its lease (2010) and relocate to a facility that meets force protection requirements. The FY 2008 budget included funds to begin design and trade studies and initial floorplan layout. A new Program Element was established for DARPA relocation expenses starting in FY 2009 (PE0605897E).

B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Management Headquarters *FY 2008 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 Design and Trade studies in preparation for a move to a force-protection compliant building. *FY 2009 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.	51.480	48.568	51.055	

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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	**PROJECT NUMBER** MH-01

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
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.				

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, PB 2010 Defense Advanced Research Projects Agency **RDT&E Budget Item Justification**	**DATE:** May 2009
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 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	.000	49.865	50.000						Continuing	Continuing
CYB-01: CYBER SECURITY INITIATIVE	.000	49.865	50.000						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 piece of the overall Cyber Security Initiative (CSI) will be 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 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	.000	50.000	50.000	
Current BES/President's Budget	.000	49.865	50.000	
Total Adjustments	.000	-.135	.000	
Congressional Program Reductions	.000	-.135		
Congressional Rescissions	.000	.000		
Total Congressional Increases	.000	.000		
Total Reprogrammings	.000	.000		
SBIR/STTR Transfer	.000	.000		

Change Summary Explanation

FY 2009

Decrease reflects a reduction for Section 8101 Economic Assumptions.

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency **RDT&E Project Justification**		**DATE:** May 2009
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	**PROJECT NUMBER** CYB-01

COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
CYB-01: CYBER SECURITY INITIATIVE	.000	49.865	50.000						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 piece of the overall Cyber Security Initiative (CSI) will be 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. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Cyber Security Initiative	.000	49.865	50.000	
(U) The goal of the National Cyber Range (NCR) is to revolutionize the Nation's ability to conduct cyber operations by providing a persistent cyber testing environment. The National Cyber Range will produce qualitative and quantitative assessments of the security of various cyber technologies and scenarios. The National Cyber Range will provide a revolutionary, safe, instrumented environment for our national cyber security research organizations to test the security of information systems. The network environment will be able to replicate complex, large-scale, heterogeneous networks and users in current and future Department of Defense (DoD) weapon systems and operations. It will also enable multiple, independent, simultaneous experiments on the same infrastructure to enable realistic testing of Internet/ Global Information Grid (GIG) scale research, and develop and revolutionize the state-of-the-art in cyber testing. *FY 2009 Plans:* - Develop detailed design specifications and concepts of operations. - Refine the specifications leading to prototype development. *FY 2010 Plans:* - Complete prototype development. - Expand the cyber range to full capability and begin transition effort.				

Exhibit R-2a, PB 2010 Defense Advanced Research Projects Agency RDT&E Project Justification		DATE: May 2009
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	**PROJECT NUMBER** CYB-01

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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