Department of Defense
Fiscal Year (FY) 2013 President's Budget Submission

February 2012

Defense Advanced Research Projects Agency

Justification Book Volume 1

Research, Development, Test & Evaluation, Defense-Wide

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Table of Volumes

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Defense-Wide
FY 2013 President's Budget
Exhibit R-1 FY 2013 President's Budget
Total Obligational Authority
(Dollars in Thousands)

24 Jan 2012

Summary Recap of Budget Activities	FY 2011 Actuals	FY 2012 Base	FY 2012 OCO	FY 2012 Total
Basic Research	287,561	328,643		328,643
Applied Research	1,132,724	1,218,603		1,218,603
Advanced Technology Development (ATD)	1,261,666	1,195,842		1,195,842
RDT&E Management Support	153,155	72,689		72,689
Total Research, Development, Test & Evaluation	2,835,106	2,815,777		2,815,777

Summary Recap of FYDP Programs	FY 2011 Actuals	FY 2012 Base	FY 2012 OCO	FY 2012 Total
Intelligence and Communications	9,949	5,000		5,000
Research and Development	2,825,157	2,810,777		2,810,777
Total Research, Development, Test & Evaluation	2,835,106	2,815,777		2,815,777

Defense-Wide
FY 2013 President's Budget
Exhibit R-1 FY 2013 President's Budget
Total Obligational Authority
(Dollars in Thousands)

24 Jan 2012

Summary Recap of Budget Activities	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Basic Research	348,727		348,727
Applied Research	1,174,673		1,174,673
Advanced Technology Development (ATD)	1,222,208		1,222,208
RDT&E Management Support	71,568		71,568
Total Research, Development, Test & Evaluation	2,817,176		2,817,176

Summary Recap of FYDP Programs	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Intelligence and Communications	1,801		1,801
Research and Development	2,815,375		2,815,375
Total Research, Development, Test & Evaluation	2,817,176		2,817,176

Defense-Wide
FY 2013 President's Budget
Exhibit R-1 FY 2013 President's Budget
Total Obligational Authority
(Dollars in Thousands)

24 Jan 2012

Appropriation	FY 2011 Actuals	FY 2012 Base	FY 2012 OCO	FY 2012 Total
Defense Adv Research Projects Agcy	2,835,106	2,815,777		2,815,777
Total Research, Development, Test & Evaluation	2,835,106	2,815,777		2,815,777

R-1C: FY 2013 President's Budget (Published Version), as of January 24, 2012 at 10:45:10

Defense-Wide
FY 2013 President's Budget
Exhibit R-1 FY 2013 President's Budget
Total Obligational Authority
(Dollars in Thousands)

24 Jan 2012

Appropriation	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Defense Adv Research Projects Agcy	2,817,176		2,817,176
Total Research, Development, Test & Evaluation	2,817,176		2,817,176

Defense-Wide
FY 2013 President's Budget
Exhibit R-1 FY 2013 President's Budget
Total Obligational Authority
(Dollars in Thousands)

24 Jan 2012

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

Line No	Program Element Number	Item	Act	FY 2011 Actuals	FY 2012 Base	FY 2012 OCO	FY 2012 Total	Sec
2	0601101E	Defense Research Sciences	01	287,561	290,773		290,773	U
4	0601117E	Basic Operational Medical Research Science	01		37,870		37,870	U
		Basic Research		287,561	328,643		328,643	
8	0602115E	Biomedical Technology	02		95,000		95,000	U
12	0602303E	Information & Communications Technology	02	239,631	354,125		354,125	U
13	0602304E	Cognitive Computing Systems	02	81,796	49,365		49,365	U
14	0602305E	Machine Intelligence	02	34,773	52,276		52,276	U
15	0602383E	Biological Warfare Defense	02	35,318	30,421		30,421	U
20	0602702E	Tactical Technology	02	205,871	202,422		202,422	U
21	0602715E	Materials and Biological Technology	02	278,704	219,816		219,816	U
22	0602716E	Electronics Technology	02	256,631	215,178		215,178	U
		Applied Research		1,132,724	1,218,603		1,218,603	
34	0603286E	Advanced Aerospace Systems	03	234,389	98,878		98,878	U
35	0603287E	Space Programs and Technology	03	88,777	97,541		97,541	U
52	0603739E	Advanced Electronics Technologies	03	181,118	150,286		150,286	U
54	0603760E	Command, Control and Communications Systems	03	200,593	261,606		261,606	U
55	0603765E	Classified DARPA Programs	03	79,824	107,226		107,226	U
56	0603766E	Network-Centric Warfare Technology	03	219,185	208,503		208,503	U
57	0603767E	Sensor Technology	03	257,780	271,802		271,802	U
		Advanced Technology Development (ATD)		1,261,666	1,195,842		1,195,842	
157	0605502E	Small Business Innovative Research	06	74,469				U

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24 Jan 2012

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

Line No	Program Element Number	Item	Act	FY 2013 Base	FY 2013 OCO	FY 2013 Total	Sec
2	0601101E	Defense Research Sciences	01	309,051		309,051	U
4	0601117E	Basic Operational Medical Research Science	01	39,676		39,676	U
		Basic Research		348,727		348,727	
8	0602115E	Biomedical Technology	02	110,900		110,900	U
12	0602303E	Information & Communications Technology	02	392,421		392,421	U
13	0602304E	Cognitive Computing Systems	02	30,424		30,424	U
14	0602305E	Machine Intelligence	02				U
15	0602383E	Biological Warfare Defense	02	19,236		19,236	U
20	0602702E	Tactical Technology	02	233,209		233,209	U
21	0602715E	Materials and Biological Technology	02	166,067		166,067	U
22	0602716E	Electronics Technology	02	222,416		222,416	U
		Applied Research		1,174,673		1,174,673	
34	0603286E	Advanced Aerospace Systems	03	174,316		174,316	U
35	0603287E	Space Programs and Technology	03	159,704		159,704	U
52	0603739E	Advanced Electronics Technologies	03	111,008		111,008	U
54	0603760E	Command, Control and Communications Systems	03	237,859		237,859	U
55	0603765E	Classified DARPA Programs	03	3,000		3,000	U
56	0603766E	Network-Centric Warfare Technology	03	236,883		236,883	U
57	0603767E	Sensor Technology	03	299,438		299,438	U
		Advanced Technology Development (ATD)		1,222,208		1,222,208	
157	0605502E	Small Business Innovative Research	06				U

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24 Jan 2012

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

Line No	Program Element Number	Item	Act	FY 2011 Actuals	FY 2012 Base	FY 2012 OCO	FY 2012 Total	Sec
165	0605897E	DARPA Agency Relocation	06	12,344	1,000		1,000	U
166	0605898E	Management HQ - R&D	06	56,393	66,689		66,689	U
176	0305103E	Cyber Security Initiative	06	9,949	5,000		5,000	U
		RDT&E Management Support		153,155	72,689		72,689	
		Total Research, Development, Test & Eval, DW		2,835,106	2,815,777		2,815,777	

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

Line No	Program Element Number	Item	Act	FY 2013 Base	FY 2013 OCO	FY 2013 Total	Sec
165	0605897E	DARPA Agency Relocation	06				U
166	0605898E	Management HQ - R&D	06	69,767		69,767	U
176	0305103E	Cyber Security Initiative	06	1,801		1,801	U
		RDT&E Management Support		71,568		71,568	
		Total Research, Development, Test & Eval, DW		2,817,176		2,817,176	

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

Budget Activity 01: Basic Research
Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

Budget Activity 02: Applied Research
Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

Budget Activity 02: Applied Research
Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

Budget Activity 03: Advanced Technology Development (ATD)
Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

Budget Activity 06: RDT&E Management Support
Appropriation 0400: Research, Development, Test & Evaluation, Defense-Wide

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012

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

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	287.561	290.773	309.051	-	309.051	315.567	328.588	342.321	359.391	Continuing	Continuing
BLS-01: *BIO/INFO/MICRO SCIENCES*	47.799	35.009	39.678	-	39.678	36.125	36.248	37.248	40.925	Continuing	Continuing
CCS-02: *MATH AND COMPUTER SCIENCES*	52.560	59.492	67.601	-	67.601	68.342	68.412	73.812	76.451	Continuing	Continuing
CYS-01: *CYBER SCIENCES*	-	16.667	25.000	-	25.000	33.333	41.667	50.000	50.000	Continuing	Continuing
ES-01: *ELECTRONIC SCIENCES*	74.477	42.145	53.163	-	53.163	37.876	45.876	36.876	36.752	Continuing	Continuing
MS-01: *MATERIALS SCIENCES*	90.916	99.506	76.340	-	76.340	76.450	76.824	79.824	90.263	Continuing	Continuing
TRS-01: *TRANSFORMATIVE SCIENCES*	21.809	37.954	47.269	-	47.269	63.441	59.561	64.561	65.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*

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

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

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

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

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

Change Summary Explanation

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

FY 2013: Increase reflects minor repricing.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** BLS-01: *BIO/INFO/MICRO SCIENCES*	

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Bio Interfaces	2.061	6.500	12.000
Description: The Bio Interfaces program supports scientific study and experimentation, emphasizing the interfaces between biology and the physical and mathematical/computer sciences. This unique interaction will develop new mathematical and experimental tools for understanding biology in a way that will allow its application to a myriad of DoD problems. These tools will help exploit the advances in the complex modeling of physical and biological phenomena. It is also expected that understanding the fundamentals of biology will aid in developing tools to understand complex, non-linear networks and force structures. This program will also explore the fundamental nature of time in biology and medicine. This will include mapping basic clock circuitry in biological systems from the molecular level up through unique species level activities with a special emphasis on the applicability to human biology. Operational relevance of this research activity includes improving our understanding of sleep-wake cycles, increasing the scientific understanding of deployment cycle lengths, and enhancing our ability to model the dynamics of disease outbreaks.			
FY 2011 Accomplishments: - Applied scientific principles of mathematical decoding to elucidate the basis of temporal-spatial signatures within biological systems, particularly with respect to human biology. - Compiled existing published techniques and approaches for deciphering temporal coding in genetic sequences and determined appropriateness of specific algorithms for elucidating periodic processes in DNA.			
FY 2012 Plans: - Identify and build a library of canonical episequence signatures that dictate spatio-temporal regulation of temporal processes using bioinformatic or data mining techniques as a stepping stone to understanding the nature of time in biology and medicine.			

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** BLS-01: *BIO/INFO/MICRO SCIENCES*

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** BLS-01: *BIO/INFO/MICRO SCIENCES*

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** BLS-01: *BIO/INFO/MICRO SCIENCES*

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

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** CCS-02: *MATH AND COMPUTER SCIENCES*

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Computer Science Study Group (CSSG)	9.415	12.000	5.100
Description: The Computer Science Study Group (CSSG) program supports emerging ideas from the computer science academic community to address the DoD's need for innovative computer and information science technologies; introduces a generation of junior researchers to the needs and priorities of the DoD; and enables the transition of those ideas and applications by promoting joint university, industry, and government projects. The CSSG project formalizes and focuses this research for efficiency and greater effectiveness. ***FY 2011 Accomplishments:*** - Selected thirteen promising computer scientists to form the Class of 2011. - Awarded grants to ten Principle Investigators (PIs) from the Class of 2010 in support of research with high payoff potential to DoD. - Initiated transition of research from CSSG PIs to several defense and intelligence organizations (i.e., PEO-Soldier Army Research, Development, and Engineering Command (RDECOM), Office of the Director of National Intelligence, Defense Intelligence Agency, and Army Research Office). ***FY 2012 Plans:*** - Transition successful research outcomes from Classes 2008-2011. - Award grants to at least nine PIs from the Class of 2011 in support of research with high payoff potential to DoD. - Award grants to at least three PIs from Class of 2009 who successfully transition their research into partnerships with other sources of funding from government or industry. ***FY 2013 Plans:***			

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** CCS-02: *MATH AND COMPUTER SCIENCES*

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

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

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

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

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: This program aimed to revolutionize the mathematical tools used by DoD in both theory and applications, discover and generate powerful and innovative new mathematics, tackle long-standing mathematical problems, and create new mathematical disciplines to meet the long-term needs of the DoD across diverse scientific and technological areas. ***FY 2011 Accomplishments:*** - Extended known links (e.g., de Rahm-Witt complexes and K-groups) between topology and algebra for continuous manifolds to the case of discrete structures. - Improved understanding of differential equations appearing in number theory, as a tool for passing between number theory and geometry.			
Accomplishments/Planned Programs Subtotals	52.560	59.492	67.601

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
CYS-01: *CYBER SCIENCES*	-	16.667	25.000	-	25.000	33.333	41.667	50.000	50.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

TBD

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
ES-01: *ELECTRONIC SCIENCES*	74.477	42.145	53.163	-	53.163	37.876	45.876	36.876	36.752	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Title: Optical Radiation Cooling and Heating in Integrated Devices (ORCHID)	5.263	2.653	7.750
Description: Many Department of Defense (DoD) systems use micro- and nano-electromechanical systems (MEMS and NEMS). These devices are used in compact accelerometers and gyroscopes for stability control in inertial navigation and in switches for optical communication and data routing. These devices operate many orders of magnitude away from their ultimate limits. Techniques to reduce or overcome thermal noise in MEMS/NEMS devices are critical for realizing their full potential. Opto-mechanical devices offer a novel, noncryogenic path toward sensing at the standard quantum limit (SQL). Ultimately, quantum (shot) noise limits the performance of many sensitive optical instruments including force sensors, trace gas detectors, and laser gyroscopes. However, opto-mechanical devices can also control the quantum fluctuations of optical probes to reduce readout sensitivity below SQL, via a technique known as squeezing. The ORCHID program will leverage recent successes within the field of cavity-opto-mechanics to broadly explore the application space while driving technological development toward smaller and more robust devices capable of deployment in the field. It is envisioned that such devices, once demonstrated, will find broad application across DoD, particularly in the areas of force sensing and optical communication. ***FY 2011 Accomplishments:***			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated devices with a cavity finesse of 10^5, an effective mass of less than 1 nanogram, resonant frequencies larger than 100 megahertz and mechanical quality factors of up to 10^7; these parameters are necessary to reach the quantum ground state of mechanical motion thus enabling high sensitivity and high bandwidth accelerometers. - Demonstrated a microwave oscillator with a phase noise of -135 decibels relative to carrier at 100 kilohertz offset from a 235 megahertz carrier signal, a record low phase noise of opto-electronic-oscillators. This is constructive progress towards applying optomechanical microwave oscillators in modern communications, multi-static radar and precision time keeping systems. - Demonstrated a record-breaking on-chip opto-mechanical optical delay line of up to 50 ns. Such on-chip delays are useful for implementing optical storage for data synchronization, small optical switches and efficient non-linear devices for lasers, amplifiers, detectors, modulators and wavelength converters. - Built first generation of opto-mechanical devices such as tunable directional couplers and mechanical memories. ***FY 2012 Plans:*** - Demonstrate a low phase noise opto-mechanical oscillator with frequency greater than 10 gigahertz; a frequency compatible for modern communication and radar systems. - Demonstrate an optical switch with switching time less than 100 nanoseconds (ns) for enhanced on-chip data processing. - Demonstrate an opto-mechanical mass sensor with 10 zeptogram sensitivity in air for molecular identification in atmospheric conditions. - Demonstrate quantum state transfer between optical and motional states for optical wavelength conversion and long distance transport of information. ***FY 2013 Plans:*** - Demonstrate an opto-mechanical mass sensor with 1 zeptogram sensitivity in air for single atom identification under atmospheric conditions. - Demonstrate an optical switch with switch time less than 10 nanoseconds for high-speed on-chip optical data processing. - Build an on-chip opto-mechanical oscillator at 11 gigahertz with a phase noise below -120 decibels relative to carrier/hertz at 100 kilohertz offset, more than 100 megahertz of continuous tunability and 2.5 gigahertz of discrete tunability. - Demonstrate the conversion of microwave phonons to optical photons for optical wavelength conversion and long distance transport of information.			
Title: Advanced X-Ray Integrated Sources (AXIS) ***Description:*** The objective of the Advanced X-Ray Integrated Sources (AXIS) program is to develop tunable mono-energetic X-ray sources that are spatially coherent with greatly reduced size, weight and power while dramatically increasing their electrical efficiency through application of micro-scale engineering technologies such as MEMS and NEMS. Such X-ray sources will enable new versatile imaging modalities based on phase contrast which are 1000X more sensitive than the conventional absorption contrast imaging. Such imaging modalities should enable reverse engineering of integrated circuits to validate trustworthiness	-	5.000	11.000

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

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

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

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

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Transition innovative concepts developed with the university program to provide novel capabilities for DoD microelectronics systems.			
Title: Quantum Entanglement Science and Technology (QuEST) ***Description:*** The Quantum Entanglement Science and Technology (QuEST) program is exploring the research necessary to create new technologies based on quantum information science. Technical challenges include loss of information due to quantum decoherence, limited communication distance due to signal attenuation, protocols, and larger numbers of quantum bits (qubits) and their entanglement. A key challenge is to integrate improved single and entangled photon and electron sources and detectors into quantum computation and communication networks. Error correction codes, fault tolerant schemes, and longer decoherence times will address the loss of information. Expected impacts include highly secure communications, algorithms for optimization in logistics, highly precise measurements of time and position on the earth and in space, and new image and signal processing methods for target tracking. ***FY 2011 Accomplishments:*** - Continued fundamental research in the area of quantum information science. - Developed novel approach to interconversion between different qubit technologies. - Developed novel qubit architectures resistant to localized noise sources. - Demonstrated new qubit readout and manipulation techniques. - Developed new theoretical insights on the impact of environmental noise on inter-qubit entanglement. ***FY 2012 Plans:*** - Continue fundamental research in the area of quantum information. - Characterize and manipulate entangled quantum systems.	19.128	5.092	-
Title: N/MEMS Science and Focus Centers ***Description:*** The goal of the N/MEMS Science and Focus Centers program was to support the development of an enhanced fundamental understanding in a number of technical issues considered to be critical to the continuing advance of nanoelectromechanical systems (NEMS) and microelectromechanical systems (MEMS) technologies and their transition into military systems. The program supported basic research at seven university centers responding to recognized challenges in a comprehensive range of technical areas pertinent to future DoD micro/nano technology needs. Industrial cost sharing was an important element of the program, with industry matching DARPA resources on a 1:1 basis. ***FY 2011 Accomplishments:*** - Demonstrated working prototypes of independently actuated dual N/MEMS probes, multilayered phase change vias with 2x lower reset current and phase change reconfigurable RF, mixed-signal and digital circuits.	6.807	-	-

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

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

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C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Nanoscale/Bio-inspired and MetaMaterials	7.983	10.000	14.140

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

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

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

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

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

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

Description: This thrust examines the fundamental physics of materials at the atomic scale in order to develop new devices and capabilities. A major emphasis of this thrust is to provide the theoretical and experimental underpinnings of a new class of semiconductor electronics based on spin degree of freedom of the electron, in addition to (or in place of) the charge. A new all optical switch capability will also be investigated. It includes a new, non-invasive method to directly hyperpolarize biological tissues, leading to novel quantitative neurodiagnostics. New materials and prototype devices will be developed to demonstrate a new class of optoelectronics that operate with ultra-low energy dissipation (~100 atom-Joules (aJ)/operation).

FY 2011 Accomplishments:
- Demonstrated production of antiferromagnetically ordered states in 2-D optical lattices.
- Studied and characterized supersolid behavior in multi-spin Bose condensates.
- Experimentally produced phase diagrams of strongly interacting fermion gases in less than twelve hours.
- Realized synthetically charged atoms and artificial magnetic fields in preparation for studies of fractional quantum Hall effect physics.
- Demonstrated all-optical switch based on optically-induced absorption.
- Demonstrated total energy dissipation for an optical switch of 2.3 attojoules per operation, and best case signal loss of less than 0.1 decibel (dB), excluding waveguide losses before and after device, at a temperature of 27 Kelvin.
- Demonstrated all-optical switching using two photon absorption with organic molecules (7C TCF cyanine, 2PA (two photon) cross-section of 750 GM (Goeppert-Mayers) when measured in processed film on silica), inverse Raman scattering with organic molecules and Zeno chi (2) effect crystals.
- Demonstrated and independently verified visible light with Orbital Angular Momentum (OAM) induces 1.5 percent nuclear polarization equivalent -- to a 2000 tesla magnet.
- Endowed a 12.8 kilo electron volt X-ray beam with OAM=40 -- the highest OAM value imparted for that X-ray energy.
- Demonstrated X-rays with OAM induces 0.15 percent nuclear polarization -- 200x larger than current state of the art.

FY 2012 Plans:
- Load polar molecules into optical lattices to study long-range character and ordering inside the optical lattice.
- Produce phase diagrams of frustrated quantum antiferromagnets.
- Produce phase diagrams of 2-D Fermi-Hubbard model at near half-filling; determine presence or absence of superfluid phase.
- Demonstrate all-optical switch (or equivalent device) based on optically-induced absorption for a 25 nanometer range in input wavelength.
- Demonstrate total energy dissipation for an optical switch (or equivalent device) of less than 100 attojoules per operation, and signal loss of less than 0.05 dB, excluding waveguide losses before and after device, at room temperature.

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

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

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

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

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

- Achieved record performance levels for compact-high-purity frequency sources. Performance confirmed by third party testing. Verified measurements significantly exceeded phase metrics: 698 MHz fundamental frequency (metric 500 MHz) with 110 decibels (dBc)/Hz phase noise (metric -90 dBc/Hz) at 1 kHz offset. Associated Allan deviation confirmed to be 0.6 parts per billion.
- Three separate nonlinear mechanisms identified that improve oscillator performance.
- Developed microscale oscillators of navigation grade. Included initial prototype in defense GPS equipment to demonstrate acquisition and tracking of GPS.
- Developed technology to hide signals with low probability of detection within an adversary's jammer.
- Achieved vibration isolation 3x10-12 /g allowing operation in vibrating systems (e.g., helicopters).

Coherent Collective Dynamics (Topological Insulators) Thrust:
- Developed physics of topological insulators guiding the production of interconnects to transmit electricity/information with orders of magnitude lower power and lower losses than the best performing known technology.
- Reproduced first ever magnet whose direction of magnetization can be controlled via applied voltage, which together with topological surface states will result in an ultra low power transistor useful well beyond the impending end of Moore's Law.
- Produced the first ever topological insulator based field effect transistor.

Information Transduction Thrust:
- Developed novel method to measure conductance produced via transduction of molecular motion, and used it to reproducibly identify individual molecule species in a large liquid background. This will allow production of the first ever handheld, accurate electronic biomolecular sensor for use in-theater.
- Produced and successfully tested the first prototypes of novel information transducers with improved performance and reduced noise.

Coherent Feedback Control Thrust:
- Completed initial specification of a computer language which engineers can use to properly design quantum stabilized nanophotonic circuits.
- Designed basic logic components requiring minimal physical resources for ultra-low power photonic digital signal processing.

FY 2012 Plans:
Nonlinearity and Noise Thrust:
- Reduce phase noise 30 decibels over existing electromechanical alternatives by using noise-driven dynamics. Meet physical size metric of 1cm3, acceleration sensitivity requirement, and temperature stability of < 30 ppm, for operating frequency of 800 MHz.

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

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

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Social Media in Strategic Communication (SMISC)*	3.571	8.300	16.720
Description: *Formerly Crowd-Sourced Analytics The Social Media in Strategic Communication (SMISC) program will develop techniques to detect, classify, measure and track the formation, development and spread of ideas and concepts (memes) in social media. This will provide warfighters and intelligence analysts with indications and warnings of adversary efforts to propagate purposefully deceptive messaging and misinformation. Social media creates vulnerabilities that can be exploited to harm U.S. interests and threaten national security and have become a key operating environment for a broad range of extremists. SMISC will develop technology and a new supporting foundational science of social networks that will enable warfighters to defend against malevolent use of social media and to counter extremist influence operations. ***FY 2011 Accomplishments:*** - Established analytical framework and defined initial approaches for quantitative assessment. ***FY 2012 Plans:*** - Develop formal representations for social context. - Apply and adapt new natural language processing techniques to social media where highly contracted forms of communication are the rule. - Develop big graph models and advanced analytics for social dynamics in social media. - Develop algorithms for detecting, classifying, measuring and tracking the formation, development and spread of ideas and concepts (memes) in social media. ***FY 2013 Plans:***			

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

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

Description: *Formerly part of Synthetic Biology

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

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

FY 2011 Accomplishments:

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

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** TRS-01: *TRANSFORMATIVE SCIENCES*

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

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** TRS-01: *TRANSFORMATIVE SCIENCES*

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	-	37.870	39.676	-	39.676	45.500	46.500	48.500	48.500	Continuing	Continuing
MED-01: *BASIC OPERATIONAL MEDICAL SCIENCE*	-	37.870	39.676	-	39.676	45.500	46.500	48.500	48.500	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Basic Operational Medical Science Program Element is budgeted in the Basic Research Activity because it will explore and develop basic research in medical-related information and technology leading to fundamental discoveries, tools, and applications critical to solving DoD challenges. Programs in this project address the Department's identified medical gaps in taking care of the warfighter such as blast-induced traumatic brain injury. Efforts will draw upon the information, computational modeling 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 establish a fundamental understanding of brain function, short-term memory and the mechanism(s) of injury induced by exposure to blast. Basic research that aims at new methods and medical devices includes the ability to perform in-theater, continuous analysis of a warfighter's health as a preventative measure to mitigate widespread disease and development of biomaterials that allow long-term interfaces with neural tissue, electronics that provide sound attenuation and processes to remove harmful bacteria and their toxins in blood to prevent sepsis.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	-	37.870	44.676	-	44.676
Current President's Budget	-	37.870	39.676	-	39.676
Total Adjustments	-	-	-5.000	-	-5.000
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• TotalOtherAdjustments	-	-	-5.000	-	-5.000

Change Summary Explanation

FY 2013: Decrease reflects minor repricing.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Human Assisted Neural Devices*	-	15.370	10.176

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: *Previously funded in PE 0601101E, Project BLS-01 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 after injury. This will require an understanding of neuroscience, significant computational efforts, and new material design and implementation. Key advances expected from this research include determining the nature and means through which short-term memory is encoded, and discovering the mechanisms and dynamics underlying neural computation and reorganization. These advances will enable memory restoration through the use of devices programmed to bridge gaps in the injured brain. Further, modeling of the brain will progress to an unprecedented level with this novel approach. ***FY 2012 Plans:*** - Assess consistency to encode long-term memory through use of patterned neural stimulation in pre-clinical models. - Identify homogeneity of neural codes involving long-term memory in preclinical studies conducting various long-term memory tasks. - Develop wireless neural interface for online, closed loop recovery of long-term memory encoding and retrieval in pre-clinical studies. - Determine whether networks of neurons can be differentially modulated through optogenetic neural stimulation in animal models. - Investigate how connectivity affects the rate at which information is transmitted between areas of the brain. - Evaluate the ability to model multi-scale brain recording and imaging data in order to accurately predict underlying spiking behavior of groups of neurons. - Investigate the ability in animal models to engage in virtual sensorimotor tasks through the use of recorded neural signals. - Determine if non-human primates can evaluate and make use of auxiliary sensory information provided solely through a neural interface. ***FY 2013 Plans:*** - Expand suite of tools and methods to enable optogenetic neuromodulation of specific, diverse neural populations in animal models. - Demonstrate ability of non-human primate to perform a dexterous sensorimotor task using only auxiliary sensory information provided through a neural interface. - Develop models that predict the evolution of neural firing patterns following brain injury, and following the introduction of artificial neural connections aimed at facilitating recovery.			

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Demonstrate the ability of non-human primates to perform a dexterous sensorimotor task through the use of a neural interface, without the use of neural spike recordings.			
Title: Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT)* ***Description:*** *Previously funded in Synthetic Biology in PE 0601101E, Project TRS-01 The Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) program will develop the underlying technologies to rapidly respond to a disease or threat, and improve individual readiness and total force health protection by providing centralized laboratory capabilities at non-tertiary care and individual settings. ADEPT will develop and exploit synthetic biology for the in vivo creation of nucleic acid circuits that continuously and autonomously sense and respond to changes in physiologic state and for novel methods to target delivery, enhance immunogenicity, or control activity of vaccines, potentially eliminating the time to manufacture a vaccine ex vivo. ADEPT advancements to control cellular machinery include research to optimize orthogonality and modularity of genetic control elements; identify methods to increase sensitivity and specificity; and demonstrate methods to control cellular machinery in response to changes in physiological status. ADEPT will develop methodologies for measuring health-specific biomarkers from a collected biospecimen to enable diagnostics at the point-of-need or resource limited clinical facilities (point-of-care), in-garrison or deployed. Additionally, ADEPT will initiate techniques to characterize natural signal transduction pathways, such as electrical and mechanical, that are not conventionally used to guide diagnosis, or as a therapeutic measure. The signals will be studied in detail and their physiological function validated for measurement and modulation to determine diagnostic and therapeutic benefit. Applied research efforts are budgeted in PE 0602115E, Project BT-01. ***FY 2012 Plans:*** - Initiate development of modular and orthogonal nucleic acid-based elements for application within a sense-and-respond circuit that operates within context of a mammalian cell. - Investigate controlled expression in mammalian cells of synthetic circuit that responds to physiological biomarkers associated with health status. - Develop novel concepts and molecular approaches to enable deployable diagnostics. - Develop novel reagents and materials for stabilizing self-collected biospecimens at room temperature for simple shipment and storage. - Develop methods for sample preparation that require no operator manipulation and are consistent with point-of-need and point-of-care settings. - Develop new methods for signal amplification amenable to deployable diagnostics. ***FY 2013 Plans:*** - Demonstrate development of modular and orthogonal nucleic acid-based elements for application within a sense-and-respond circuit that operates within context of a mammalian cell.	-	17.500	24.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Demonstrate controlled expression in mammalian cells of synthetic circuit that responds to physiological biomarkers associated with health status. - Quantify performance of developed molecular approaches designed for deployable diagnostics. - Quantify performance of biostabilization reagents/materials. - Quantify performance of methods for room temperature analyses and reagent stabilization. - Quantify detection limits achieved with signal amplification methods. - Demonstrate performance of new sample preparation methods suitable for simple and multiplexed analysis off of biospecimens that are either self-collected under low-resource settings or collected by trained professionals at the physician-office settings. - Design integration of developed diagnostic methodologies. - Investigate bioelectric signatures and signaling patterns related to biological responses, such as baseline status and regenerative tissue conditions. - Characterize bio-electric signaling from multiple cell types/biological environments.			
Title: Dialysis-Like Therapeutics ***Description:*** Sepsis, a bacterial infection of the blood stream, is a significant cause of injury and death among combat-injured soldiers. The goal of this program is to develop a portable device capable of controlling relevant components in the blood volume on clinically relevant time scales. Reaching this goal is expected to require significant advances in sensing in complex biologic fluids, complex fluid manipulation, separation of components from these fluids, and mathematical descriptions capable of providing predictive control over the closed loop process. The envisioned device would save the lives of thousands of military patients each year by effectively treating sepsis and associated complications. Initial basic research will develop the component technologies that will ultimately make up the integrated device. Included in this effort will be the development of non-fouling, continuous sensors for complex biological fluids; design of high-flow microfluidic structures that do not require the use of anticoagulation; development of intrinsic separation technologies that do not require pathogen specific molecular labels or binding chemistries; and predictive modeling and control (mathematical formalism) with sufficient fidelity to enable agile adaptive closed-loop therapy. Applied research efforts are budgeted in PE 0602115E, Project BT-01. ***FY 2012 Plans:*** - Achieve intermittent sensing technologies for the detection of pathogens and biomolecules in flowing blood, blood components, and wound fluid at least every 45 minutes with more than 2 hours of continuous operation. - Attain microfluidic architectures and coatings for 100 mL/hr microfluidic system blood flow for at least 2 hours without platelet activation or clotting.	-	5.000	5.000

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601117E: *BASIC OPERATIONAL MEDICAL SCIENCE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Accomplish 50% removal of pathogens and select bioagents from blood or blood components via label free separation technologies. - Demonstrate a clinically relevant sepsis predictive model and training algorithm based on data sets from published literature. ***FY 2013 Plans:*** - Improve intermittent sensing technologies for the continuous detection of pathogens and biomolecules in flowing blood, blood components, and wound fluid. - Refine microfluidic architectures and coatings for continuous blood flow without platelet activation or clotting. - Enhance label-free separation technologies to successfully remove pathogens and select bioagents from blood or blood components. - Validate the sepsis predictive modeling using larger anonymous clinical datasets.			
Accomplishments/Planned Programs Subtotals	-	37.870	39.676

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602115E: *BIOMEDICAL TECHNOLOGY*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	-	95.000	110.900	-	110.900	97.069	104.742	121.603	127.881	Continuing	Continuing
BT-01: *BIOMEDICAL TECHNOLOGY*	-	95.000	110.900	-	110.900	97.069	104.742	121.603	127.881	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Program Element is budgeted in the applied research budget activity because it will focus on medical related technology, information, processes, materials, systems, and devices encompassing a broad spectrum of DoD challenges. Biowarfare defense includes the capability to predict and deflect pathogen evolution of natural and engineered emerging threats and therapeutics that increase survivability within days of receipt of an unknown pathogen. Continued understanding of infection biomarkers will lead to developing a detection device that can be self-administered and provide a faster ability to diagnose and prevent widespread infection in-theater. Other battlefield technologies includes a soldier-portable hemostatic wound treatment system, capability to manufacture field-relevant pharmaceuticals in theater, and a rapid after-action review of field events as a diagnostic tool for improving the delivery of medical care and medical personnel protection. Improved medical imaging will be approached through new physical properties of cellular metabolic activities. New neural interface technologies will reliably extract information from the nervous system to enable control of the best robotic prosthetic-limb technology. To allow medical practitioners the capability to visualize and comprehend the complex relationships across patient data in the electronic medical record systems, technologies will be developed to assimilate and analyze the large amount of data and provide tools to make better informed decisions for patient care. In the area of medical training, new simulation-based tools will rapidly teach increased competency in an open and scalable architecture to be used by all levels of medical personnel for basic and advanced training. Advanced information-based techniques will be developed to supplement warfighter healthcare and the diagnosis of post-traumatic stress disorder (PTSD) and mild traumatic brain injury (mTBI). This project will also pursue the applied research efforts for dialysis-like therapeutics.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	-	110.000	95.400	-	95.400
Current President's Budget	-	95.000	110.900	-	110.900
Total Adjustments	-	-15.000	15.500	-	15.500
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-15.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• TotalOtherAdjustments	-	-	15.500	-	15.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602115E: *BIOMEDICAL TECHNOLOGY*

Change Summary Explanation

FY 2012: Decrease reflects reductions for unsustained funding.

FY 2013: Increase reflects consolidation of all budget activity 2 medical efforts into this PE.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Unconventional Therapeutics* ***Description:*** * Previously funded in PE 0602383E, Project BW-01 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. This program will develop approaches to counter any natural or man-made pathogen within one week. This includes development of countermeasures that do not require prior knowledge of the pathogen and are broadly applicable to multiple unrelated bacterial and/or viral infectious agents. The integration of academic research programs with pharmaceutical development efforts will result in reducing the traditional drug development cycle timeframe. ***FY 2012 Plans:*** - Demonstrate various technologies that can increase the median infectious dose of a given pathogen by 100-fold in an animal model compared to the untreated control in order to prevent infection. - Demonstrate a 4-fold increase in survival time after a lethal dose challenge of a given pathogen in an animal model due to administered technology. - Demonstrate 95% survival against a first lethal dose challenge of a given pathogen in an animal model using a therapy developed within 7 days of receipt of an unknown pathogen. - Demonstrate 95% three week survival after three lethal dose challenges of a given pathogen in an animal model spaced 1 week apart. ***FY 2013 Plans:*** - Demonstrate 95% survival after three lethal dose challenges of an unknown pathogen in two-animal models. - Transition good laboratory practice approved technology to U.S. pharmaceutical company for clinical development.	-	8.716	3.000
Title: Pathogen Defeat* ***Description:*** *Previously funded in PE 0602715E, Project MBT-02 Pathogens are well known for the high rate of mutation that enables them to escape drug therapies and primary or secondary immune responses. The Pathogen Defeat thrust area will provide capabilities to predict and deflect future threats. Pathogen Defeat focuses not on the threats that are already known but rather on the threats of newly emerging pathogens and future mutations, allowing pre-emptive preparation of vaccine and therapy countermeasures.	-	19.000	16.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602115E: *BIOMEDICAL TECHNOLOGY*	

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2012 Plans: - Develop a platform to reproducibly demonstrate the evolutionary pathway of a virus under multiple selective pressures. - Validate predictive algorithms against selected experimental pressures on viral evolutionary pathways. - Use algorithm to investigate virus mitigation and frequency globally to predict the timing and geographic location of reassortment events. - Model processes to accurately predict the drift and shift of virus in pre-human, animal reservoirs. - Develop first-ever system for anticipating evolution of clinical drug resistance through the use of an in vitro viral-evolution reactor. - Demonstrate novel sequencing technologies to reduce error rate. - Demonstrate evolution in microdroplet cell-viral infection systems. ***FY 2013 Plans:*** - Predict timing of antiviral failure in chronically infected viral host (animal) model. - Predict location(s) of genetic mutation responsible for antiviral failure in a chronically infected viral host (animal) model. - Predict number of viral generations necessary to achieve antiviral resistance in a chronically infected viral host (animal) model. - Predict location of genetic mutation(s) responsible for resistance to subunit vaccine (such as hemagglutinin or recombinant protective antigen.) - Correlate influenza vaccine failure in syngeneic/specific pathogen-free poultry with pathogen evolution in the natural ecologies of Asia. - Use in vitro evolution reactors to predict emergence of novel, variant influenza strains from within-reservoir species. - Use in vitro evolution reactors to predict emergence of dengue virus mutations in a region where dengue has recently appeared. - Use in vitro evolution reactors to predict host resistance to candidate pathogens.			
Title: Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT)* ***Description:*** *Previously funded in Synthetic Biology in PE 0601101E, Project TRS-01 The overarching goal of the Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) program is to increase our ability to rapidly respond to a disease or threat and improve individual readiness and total force health protection by providing centralized laboratory capabilities at non-tertiary care settings. ADEPT will focus on the development of Ribonucleic Acid (RNA)-based vaccines, potentially eliminating the time and labor required for traditional manufacture of a vaccine while at the same time improving efficacy. ADEPT will also focus on advanced development of key elements for simple-to-operate diagnostic devices. A companion basic research effort is budgeted in PE 0601117E, Project MED-01. ***FY 2012 Plans:***	-	10.508	15.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602115E: *BIOMEDICAL TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Increase stability of RNA-based vaccines. - Demonstrate efficacy of RNA-based vaccines in a small animal model. - Develop advanced instrumentation approaches for sample preparation for diagnostics. - Develop advanced instrumentation approaches for detector elements of autonomous diagnostics devices. ***FY 2013 Plans:*** - Demonstrate increased humoral and cellular responses with RNA-based vaccines as compared to benchmark vaccines in vivo. - Demonstrate increased efficacy of RNA-based vaccines in vivo in small and large animal models. - Demonstrate quantitative performance metrics for developed instrumentation approaches for diagnostic sample preparation. - Demonstrate quantitative performance metrics for developed instrumentation approaches for detector elements of autonomous diagnostic devices.			
Title: Tactical Biomedical Technologies* ***Description:*** *Previously funded in PE 0602715E, Project MBT-02 The Tactical Biomedical Technologies thrust will develop new approaches to deliver life-saving medical care on the battlefield. Uncontrolled blood loss is the leading cause of preventable death for soldiers on the battlefield. While immediate control of hemorrhage is the most effective strategy for treating combat casualties and saving lives, currently no method other than surgical intervention can effectively treat intracavitary bleeding. A focus in this thrust is the co-development of a materials-based agent(s) and delivery mechanism capable of damaged tissue-targeted hemostasis and wound control. This system will effectively treat compressible and non-compressible wounds regardless of geometry or location. Additionally, rapid response to emerging biological threats on the battlefield is impacted by logistical delays of delivering the necessary therapeutics. Creating a "pharmacy on demand" will enable far-forward medical providers to manufacture and produce small molecule drugs and biologics in order to ensure that the therapeutics are available when they need them. This project will also develop new algorithms, protocols, and methods to allow registration and comparison of disparate sources of data in biology (across species, experimental systems, hierarchies and populations). ***FY 2012 Plans:*** - Demonstrate hemostasis agent stability consistent with operational requirements. - Demonstrate hemostasis in less than four minutes on a non-compressible injury model. - Demonstrate that hemostatic material does not induce intracavitary fibrosis within 28 days when left at the wound site. - Design scale-up for large-volume hemostasis agent synthesis. - Initiate discussions for wound stasis system FDA approval.	-	16.676	18.500

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Synthesize active pharmaceutical ingredients (APIs) in continuous flow, and design and test drug product crystallization and formulation for pharmaceuticals for the battlefield. ***FY 2013 Plans:*** - Demonstrate a combined hemostasis agent and delivery mechanism that achieves hemostasis in less than four minutes, and does not interfere with standards of care. - Finalize a plan for wound stasis system FDA approval. - Demonstrate continuous flow synthesis and manufacturing of multiple pharmaceuticals using integrated platform. - Synthesize in continuous flow APIs in multiple pharmaceuticals. - Design and test drug product crystallization and formulation in multiple pharmaceuticals. - Engage the FDA for input on process analytical technologies (PAT) and current good manufacturing practice (cGMP). - Develop prototype device for treatment of intracranial hemorrhage using laser energy through the skull and tissues. - Develop advanced techniques to extract and evaluate both lexical and prosodic features from speech data collected from individuals linked to suicide risk in previous studies, and begin developing predictive models for depression and suicide assessment using speech biomarkers.			
Title: Military Medical Imaging* ***Description:*** *Previously funded in PE 0602715E, Project MBT-02 The Military Medical Imaging thrust will develop medical imaging capabilities to support military missions and operations. The emergence of advanced medical imaging includes newly recognized physical properties of biological tissue, or metabolic pathway, or physiological function in order to map it into an image of diagnostic utility and performance. This need is ever increasing as researchers and scientists seek to better understand anatomical, functional and cellular level interactions. This thrust will also address how to improve the delivery of medical care and medical personnel protection by building a simulated environment for rapid after-action review of field events generated from current military systems. The advanced development of these tools will provide a formidable arsenal of diagnostic tools for warfighter performance and care. ***FY 2012 Plans:*** - Develop software to convert disparate data formats into a common language, enabling visual display and integration for processing queries. - Demonstrate ability to automatically detect, track, and analyze similar events and incidents in temporal and physical space. - Focus x-rays with orbital angular momentum (OAM) through a model of skin and bone to a depth of 5 cm to continue work on new imaging technology comparable to magnetic resonance imaging, but not requiring a magnet. - Develop high efficiency x-ray optics appropriate for broadband, bench top x-ray sources.	-	7.334	6.900

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602115E: *BIOMEDICAL TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Increase signal-to-noise ratio using arrays of OAM photon beams and new signal detection approaches. ***FY 2013 Plans:*** - Obtain hydrogen and carbon-13 spectra from animal tissue using quantum orbital resonance spectroscopy (QORS) with potential applications for military medical use (i.e. analysis of traumatic brain injury utilizing imagery and spectroscopy information). This technique does not use a large magnet to hyperpolarize the nuclei, and may yield image and chemical information superior to an MRI, but with portability. - Design a compact prototype device for performing novel MRI-like imaging and spectroscopy using QORS in military medical environments.			
Title: Reliable Neural-Interface Technology (RE-NET)* ***Description:*** *Previously funded in PE 0602715E, Project MBT-02 Wounded warriors with amputated limbs cannot fully exploit recent advances in prosthetic-limb technology because the neural interfaces used to extract limb-control information are low-performance and unreliable. The goal of the Reliable Neural-Interface Technology (RE-NET) program is to develop the technology and systems needed to reliably extract information from the nervous system at the scale and rate necessary to control state-of-the-art high-performance prosthetic limbs. The program will increase the channel-count (amount information) of reliable peripheral-nervous-system interfaces and increase the operational lifetime (reliability) of central-nervous-system interfaces. In support of these efforts, the RE-NET program is developing methods to quantitatively assess, model, predict, and accelerate the leading causes of neural interface degradation and failure. Through this focus on reliability, the RE-NET program will enable clinically relevant technology transitions in support of wounded warriors. ***FY 2012 Plans:*** - Develop a tactor-array system for use in veterans with upper-limb amputations. These systems will be provided to U.S. veterans for long-term daily use in order to incorporate touch percepts from the prosthetic fingertips into the body schema. This effort aims to dramatically increase the functionality and use of existing advanced prosthetic systems by creating a reliable sensory-feedback interface. - Develop wearable sensor arrays that detect bioelectrical signals from muscle activity associated with hand grasp and motor activity in amputees. Develop sophisticated decoding algorithms based on sparse principal-component analysis and probabilistic modeling via Markov random fields. By selecting the optimal signal vectors, muscle-activity classification is expected to achieve very high accuracy. - Develop a peripheral-nerve interface that will form a long-term and reliable connection between the severed motor and sensory fascicles of an amputee and the electrical recording devices that will drive a robotic prosthetic limb. Decoding motor and sensory algorithms will be developed to translate control and sensation signals across the interface.	-	24.000	12.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602115E: *BIOMEDICAL TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop peripheral nerve recording interfaces and control algorithms that capture motor intent signals from the residual nerves in amputees. - Develop sophisticated real-time classification algorithms designed to operate dextrous control of an upper limb neuroprosthetic using electroencephalogram and other signals captured entirely from non-invasive, non-penetrating, sources. - Develop biotic/abiotic neural interface technology to overcome known failure mechanisms. - Replace linear and low-order, non-linear decoding techniques with sophisticated statistical and non-linear algorithms. - Develop a novel neural interface that will be implanted via a minimally invasive intravascular approach. - Enlist commercial neural interface manufacturers to develop tools to allow users to evaluate probe reliability in situ, helping them to pinpoint the source of failure should it be due to flaws in the probe design or manufacture. - Develop techniques and standards to evaluate the long-term biocompatibility of advanced neural interface materials. Collaborate with FDA and American National Standards Institute (ANSI) to adapt biocompatibility safety standards for neural interfaces. ***FY 2013 Plans:*** - Demonstrate a tactor-array system capable of driving neural plasticity and sensory percept reorganization through remapping of fingertip touch percepts to amputee residual limbs. - Demonstrate wearable bioelectric sensor array with 32 active differential channels capable of controlling a standard myoelectric prosthetic hand. Extend sophisticated electromyography (EMG)-decoding algorithms to adapt to real-world artifacts and to infer user intent. - Develop clinically viable self-contained implantable EMG-recording sensors that would have a direct and immediate impact on traditional myoelectric prostheses and transplanted muscle re-innervation patients by substantially increasing the number of controllable independent degrees of freedom. - Demonstrate the biological stability, durability, and reliability of a peripheral nerve interface through motor, sensory, and closed-loop behavioral activities in a freely moving animal model. - Initiate clinical trials for peripheral nerve recording interfaces that capture motor control signals from the endogenous residual nerves. - Demonstrate an electroencephalogram-based fully non-invasive, non-penetrating, neural-interface system capable of providing prosthetic limb control for human users. - Demonstrate the improved reliability of newly developed neural probe technologies designed specifically to overcome known failure mechanisms. - Demonstrate use of best-of-breed statistical and non-linear decoding algorithms and quantify the improvements in accuracy and reliability.			
Title: Dialysis-Like Therapeutics	-	5.000	11.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602115E: *BIOMEDICAL TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: Sepsis, a bacterial infection of the blood stream, is a significant cause of injury and death among combat-injured soldiers. The goal of this program is to develop a portable device capable of controlling relevant components in the blood volume on clinically relevant time scales. Reaching this goal is expected to require significant advances in sensing in complex biologic fluids, complex fluid manipulation, separation of components from these fluids, and mathematical descriptions capable of providing predictive control over the closed loop process. The envisioned device would save the lives of thousands of military patients each year by effectively treating sepsis and associated complications. Applied research under this program further develops and applies existing component technologies and then integrates these to create a complete blood purification system for use in the treatment of sepsis. Included in this effort will be development, integration and demonstration of non-fouling, continuous sensors for complex biological fluids; implementation of high-flow microfluidic structures that do not require the use of anticoagulation; application of intrinsic separation technologies that do not require pathogen specific molecular labels or binding chemistries; and refinement of predictive modeling and control (mathematical formalism) with sufficient fidelity to enable agile adaptive closed-loop therapy. The basic research part of this program is budgeted in PE 0601117E, Project MED-01. ***FY 2012 Plans:*** - Evaluate existing sensing, microfluidic flow, and intrinsic separation component technologies for use in an integrated blood purification system and initiate research plan to achieve significant improvements in line with the overall program goals. - Develop integration plan for component technologies developed in the basic research aspect of this program. - Develop regulatory pathway leading to an approved integrated device. ***FY 2013 Plans:*** - Refine integration strategy, develop a bread-board system, and demonstrate bread-board system in a small animal model. - Confirm regulatory plan and begin regulatory approval process for the integrated device.			
Title: Warrior Web ***Description:*** Warrior Web, previously funded in the Maintaining Combat Performance Thrust in PE 0602715E, Project MBT-02, will develop an adaptive, compliant, nearly transparent, quasi-active joint support system to mitigate acute injuries caused by physically demanding events common to missions such as airborne and air assault insertions. Warrior Web represents an expansion of capability beyond "lightening the load." Warrior Web's capability space is between biomechanics, robotics, physiology, and combat clothing. This program will result in technology that reduces the injuries sustained by soldiers. Allowing soldiers to perform their missions with reduced risk for injuries will have immediate effects on mission readiness, soldier survivability, and mission performance.	-	-	10.250

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Component technologies will be in areas such as regenerative kinetics at joints and energy harvesting to offset power/energy demands; human performance, system, and component modeling; novel materials and dynamic stiffness; actuation; controls and human interface; and power distribution/energy storage. The final suit is planned to weigh no more than 20 pounds and require no more than 100W of external power. ***FY 2013 Plans:*** - Conduct core technologies Preliminary Design Review. - Completion of preliminary core technology efforts: subsystem testing, analysis, and validated modeling. - Initiate design of suit combining core technologies. - Integrate core technologies into suit design. - Begin critical design towards a prototype.			
Title: Detection and Computational Analysis of Psychological Signals (DCAPS) - Medical* ***Description:*** *Formerly Healing Heroes - Medical. Previously funded in PE 0602304E, Project COG-03. The Detection and Computational Analysis of Psychological Signals (DCAPS) program will develop automated information systems that identify group and individual trends indicative of post-traumatic stress disorder (PTSD) and traumatic brain injury (TBI), anomaly detection algorithms to identify emerging physical and psychological crises, and provide guided access to information and educational materials. This will complement commercial on-line resources, interactive media, and social networks that supplement traditional healthcare options but have not focused on issues specific to the warfighter. DCAPS recognizes that security and privacy are critical to user acceptance and Health Insurance Portability and Accountability Act (HIPAA) compliance and so will incorporate strong authentication and other security mechanisms as needed to protect patient data. The program will also develop partnerships with key DoD organizations working in this area, including the Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury, the Defense Medical Research and Development Program, the Army Telemedicine & Advanced Technologies Research Center, and the National Center for TeleHealth and Technology. ***FY 2013 Plans:*** - Operationalize/harden system software and obtain approvals to conduct user trials. - Perform user trials of mobile psychological health and telehealth applications in coordination with transition partners. - Modify and optimize mobile psychological health and telehealth applications based on the results of user trials. - Obtain final certifications and accreditation and deliver technology to military health community transition partners.	-	-	9.000
Title: Revolutionizing Prosthetics* ***Description:*** *Previously funded in PE 0602715E, Project MBT-02.	-	-	7.250

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602115E: *BIOMEDICAL TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
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 and 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 re-acquire full functionality and return to military service if so desired. The advances required to provide fully functional limb replacements will be achieved by an aggressive, milestone driven program combining the talents of scientists from diverse areas including: medicine, neuroscience, orthopedics, engineering, materials science, control and information theory, mathematics, power, manufacturing, rehabilitation, psychology and training. The results of this program will radically improve the ability of combat amputees to return to normal function. ***FY 2013 Plans:*** - Complete demonstration of neural control of arms with closed-loop feedback by spinal cord injured patients. - Demonstrate safety and stability of sensory feedback over multiple month periods. - Finalize and submit complete FDA package to obtain approval for commercial production of neural interface devices. - Support transition efforts of neural recording and stimulation devices.			
Title: Preventing Violent Explosive Neurologic Trauma (PREVENT) ***Description:*** The Preventing Violent Explosive Neurologic Trauma (PREVENT) program seeks to understand the causes of blast-induced traumatic brain injury (TBI), 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 in-theater conditions to assess potential TBI 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. The program will combine raw data collected from in-theater blast gauges with medical and event reports to conduct a complete analysis. As part of the mitigation and treatment strategy, candidate therapeutics are being tested in order to alleviate inflammation from both acute and chronic injury. This program continues efforts previously funded in PE 0602715E, Project MBT-02. ***FY 2012 Plans:*** - Continue longitudinal study on warfighters pre- and post-deployment in order to relate specific in-theater blast exposure to evidence and rates of blast TBI. - Further examine mechanisms of blast TBI by expanding porcine population and conducting analysis of imaging, proteomics and histopathology and showing relevancy to observed warfighter injuries. - Transition and support studies of therapeutic strategies to military medical community.	-	3.766	-
Accomplishments/Planned Programs Subtotals	-	95.000	110.900

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602115E: *BIOMEDICAL TECHNOLOGY*	

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012

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

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	239.631	354.125	392.421	-	392.421	428.541	455.164	457.831	493.760	Continuing	Continuing
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	74.976	85.358	107.371	-	107.371	115.168	115.092	116.092	121.704	Continuing	Continuing
IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*	109.608	178.419	170.642	-	170.642	174.185	185.491	190.491	195.808	Continuing	Continuing
IT-04: *LANGUAGE TRANSLATION*	55.047	67.015	64.408	-	64.408	72.521	71.248	51.248	51.248	Continuing	Continuing
IT-05: *CYBER TECHNOLOGY*	-	23.333	50.000	-	50.000	66.667	83.333	100.000	125.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

The High Productivity, High-Performance Responsive Architectures project is developing the necessary 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 supercomputer, embedded computing systems, and novel design tools for manufacturing of defense systems.

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.

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 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.

The Cyber Technology project supports long term national security requirements through the development and demonstration of technology to increase the security of military information systems. This involves networking, people, platforms, weapons sensors, and decision aids to create a whole that is greater than the sum of its parts. The results are networked forces that operate with increased speed and synchronization and are capable of achieving massed effects without the physical massing of forces as required in the past.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	281.262	400.499	368.621	-	368.621
Current President's Budget	239.631	354.125	392.421	-	392.421
Total Adjustments	-41.631	-46.374	23.800	-	23.800
• Congressional General Reductions	-1.287	-			
• Congressional Directed Reductions	-28.000	-46.374			
• Congressional Rescissions	-5.837	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.011	-			
• SBIR/STTR Transfer	-6.518	-			
• TotalOtherAdjustments	-	-	23.800	-	23.800

Change Summary Explanation

FY 2011: Decrease reflects reductions for the Section 8117 Economic Adjustment, contract award delays, rescissions, and the SBIR/STTR transfer offset by internal below threshold reprogrammings.
FY 2012: Decrease reflects reductions for unsustained funding and reduction to new starts.
FY 2013: Increase reflects increased emphasis on fab-less design manufacturing, more efficient high performance computing and cyber security.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**PROJECT** IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	74.976	85.358	107.371	-	107.371	115.168	115.092	116.092	121.704	Continuing	Continuing

A. Mission Description and Budget Item Justification

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 will also focus on novel design tools for the manufacture of complex ground and aerospace systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: META ***Description:*** The goal of the META program is to develop novel design flows, tools, and processes to enable a significant improvement in the ability to design complex defense and aerospace systems that are correct-by-construction. The program seeks to develop a design representation of meta-language and a domain-specific component model library from which system designs can quickly be assembled and their correctness verified with a high degree of certainty. Such a "fab-less" design approach is complemented by a foundry-style manufacturing capability, consisting of a factory capable of rapid reconfiguration between a large number of products and product variants through bitstream reprogramability, with minimal or no resultant learning curve effects. Together, the fab-less design and foundry-style manufacturing capability is anticipated to yield substantial---by a factor of five to ten---compression in the time to develop and field complex defense and aerospace systems. The META effort will also explore the initial design of a next generation ground vehicle by employing a novel, model-based correct-by-construction design capability, a highly-adaptable foundry-style manufacturing capability, and crowd-sourcing methods to demonstrate 5x-10x compression in the timeline necessary to build an infantry fighting vehicle. Beginning in FY 2012, the specific ground vehicle application work will be funded in PE 0602702E, Project TT-04, Advanced Land Systems. ***FY 2011 Accomplishments:***	49.000	56.000	75.000

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*	PROJECT IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Continued development and integration of supporting tools necessary to implement the model-based design, integration, and verification flows. - Continued development of a foundry configuration toolset to enable the (re)configuration of foundry-style manufacturing capabilities for a given required degree of manufacturing adaptability. - Exercised feedback loop between manufacturability constraints and the system design toolset. - Continued development and testing of crowd-sourced design infrastructure for electromechanical and software systems for a next generation ground combat vehicle. ***FY 2012 Plans:*** - Mature the initial set of tools developed to implement model-based design, integration and verification to a productized version that may be released for open use with an appropriate license and will be utilized by the crowd-sourced design infrastructure. - Develop a domain-specific component model library for the drivetrain/mobility subsystems and the chassis/survivability systems of a military ground vehicle through extensive characterization of desirable and spurious interactions, dynamics, and properties of all constituent components down to the numbered part level. - Develop context models to reflect various operational environments. - Develop a domain-specific foundry configuration for military ground vehicles. - Begin the assembly and integration of foundry-style manufacturing capability for military ground vehicles. - Develop and implement an infrastructure for publishing and maintaining detailed component models using the metalanguage construct to expand the design space for subsequent efforts to design and build a military ground vehicle. - Develop a mechanism for the feedback of manufacturability constraints into the design and design tradespace exploration process. - Develop and integrate a library of various fabrication processes and associated manufacturing elements, i.e., machines and techniques employed to produce the various constituent elements of the military ground vehicle. ***FY 2013 Plans:*** - Develop a domain-specific component model library for an entire military ground vehicle through extensive characterization of desirable and spurious interactions, dynamics, and properties of all constituent components down to the numbered part level. - Finalize development of the foundry-style manufacturing capability for military ground vehicles. - Utilize the iFAB foundry to fabricate the drivetrain and mobility subsystem winning design from the related challenge. - Utilize the iFAB foundry to fabricate the chassis and survivability subsystem winning design from the related challenge.			
Title: Power Efficiency Revolution For Embedded Computing Technologies (PERFECT)* ***Description:*** * Includes aggregation of the Ubiquitous High Performance Computing (UHPC) and Architecture Aware Compiler Environment (AACE) programs.	22.270	24.126	25.371

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
The Power Efficiency Revolution For Embedded Computing Technologies (PERFECT) program will provide the technologies and techniques to overcome the power efficiency barriers which currently constrain embedded computing systems capabilities and limit the potential of future embedded systems. The warfighting problem this program will solve is the inability to process future real time data streams. This is a challenge for embedded applications, from Intelligence, Surveillance and Reconnaissance (ISR) systems on unmanned air vehicles through combat and control systems on submarines. The PERFECT program will overcome processing power efficiency limitations using threshold voltage operation, massive and heterogeneous processing concurrency, new architecture concepts, hardware and software approaches to address system resiliency, combined with software approaches to effectively utilize resulting system concurrency to provide the required embedded system processing power efficiency. ***FY 2011 Accomplishments:*** - Identified, researched, and initiated the evaluation of critical technologies, system methodologies, and architectures supporting UHPC program goals. - Completed the description of two UHPC challenge problems, synthetic aperture radar processing and graph-analysis. - Released static system characterization tools to enhance compiler performance. - Developed automatic idiom recognition tool (identify patterns of computation and data access) to support algorithm analysis, development, and implementation. ***FY 2012 Plans:*** - Complete UHPC high level architectural designs. - Release runtime system support tools for attributing runtime costs and pinpointing system performance and stability bottlenecks. - Develop interactive compilation framework incorporating affine (linear loop parallelization) and software pipelining (find and exploit parallelization in serial codes) optimizations to automate code parallelization. - Release dynamic system and performance characterization tools to enhance compiler performance via runtime performance feedback, incorporating the use of off line learning engines. ***FY 2013 Plans:*** - Discover power kernels for embedded DoD applications, including intelligence, surveillance and reconnaissance (ISR) and encryption capabilities. - Establish initial simulation infrastructure for evaluating temporal and power efficiency for DoD embedded subsystems. - Develop theoretical near threshold voltage and resiliency trade-offs for power efficiency, to be followed by experimental validation. - Identify key language extensions and approaches required for the development of massively parallel software.			
Title: Military Critical Clouds (MCC)	-	-	7.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Military Critical Clouds (MCC) program will bring the advantages of the cloud computing paradigm to mission-critical military applications and combat systems. The advantages of cloud computing have been demonstrated in civilian and Government applications to include the efficient utilization of computing resources, enabling deployed systems to be upgraded in the field, and reduced recurring and non-recurring costs. With cloud computing, myriad one-of-a-kind, single platform specific processing implementations are eliminated and replaced with application effective computing on common hardware. To date, the cloud computing paradigm has not been effectively exploited in embedded military applications, for reasons related to performance and correctness constraints. In order to apply the cloud paradigm to military systems, MCC will make significant advances in the areas of virtualization, real-time responsiveness, reliability and verifiability, and security, while taking advantage of the cloud computing paradigm's inherent cost efficiency, manufacturing agility, maintainability, and programming democratization. Fully realizing these capabilities will open the door to "platform clouds" that provide dramatically improved effectiveness in our military combat systems. ***FY 2013 Plans:*** - Develop an overarching architecture and operational concept that applies the cloud computing paradigm to selected mission-critical military applications and combat systems. This will include the interactions of real-time requirements, quality of service guarantees, dynamic adaptivity, and system-level performance verification. - Create a modeling and simulation capability and quantify the potential improvement of cloud-based combat systems vice conventional approaches. - Define challenge problems, based on existing and near-term future DoD embedded systems. These problems will be used to focus research and assess progress.			
Title: High-Productivity Computing Systems (HPCS) ***Description:*** The High-Productivity Computing Systems (HPCS) program is creating a new generation of economically viable, high-productivity computing systems for the national security and industrial user communities. HPCS technologies will enable nuclear stockpile stewardship, weapons design, cryptanalysis, weather prediction, and other large-scale problems that cannot be addressed productively with today's computers. The goal of this 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 engineers and scientists can better harness the power of high-performance computers. ***FY 2011 Accomplishments:*** - Fabricated and tested the final version of a terabits-per-second hub chip that will enable the first petascale system with global shared memory.	3.706	5.232	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Constructed, tested and started software integration of the first compute blades containing final version of all hardware components. ***FY 2012 Plans:*** - Monitor the two HPCS performers until program completion and complete prototype demonstrations with stakeholders.			
Accomplishments/Planned Programs Subtotals	74.976	85.358	107.371

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*	109.608	178.419	170.642	-	170.642	174.185	185.491	190.491	195.808	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Information Assurance and Survivability project is developing the core computing and networking technologies required to protect DoD's information, information infrastructure, and mission-critical information systems. These technologies will enable DoD information systems to operate correctly and continuously even when they are attacked, and will provide cost-effective security and survivability solutions. Technologies developed under this project will benefit other projects within this program element as well as projects 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 projects that require secure, survivable, network-centric information systems.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Cyber Genome	13.000	24.000	20.160
Description: The Cyber Genome program develops techniques to automatically characterize, analyze, and identify malicious code and determine the evolutionary relationship between new never-before-seen malware samples and older known malware. This enables the automatic detection and extermination of future malware variants. Such automation is critically important because the global production of malware is growing explosively and threatens to overwhelm current labor-intensive practices. Cyber Genome also develops advanced capabilities to enable positive identification of malicious code substructures and functionality. ***FY 2011 Accomplishments:*** - Expanded and refined technologies, ontologies, and algorithms to enable the characterization of future malicious code variants based on analyzed malicious code substructures. - Completed integration of automatic discovery, identification, analysis, and prediction algorithms. - Completed initial experiments on a large commercial mass-infection malware data set. ***FY 2012 Plans:*** - Create lineage trees for a class of digital artifacts for better software evolution forensics. - Generate execution trees from submitted malware that include automated analysis of software dependencies. - Implement techniques in a prototype system, demonstrate, and commence transition. ***FY 2013 Plans:*** - Extend and refine lineage trees for a class of digital artifacts.			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Extend execution trees from submitted malware that include automated analysis of software dependencies. - Develop operationally relevant use-case test scenarios with transition partner and conduct initial use case validation tests.			
Title: Integrity Reliability Integrated CircuitS (IRIS)	22.878	30.000	20.000

Description: The U.S. military now consumes only approximately one percent of the total integrated circuit (IC) production in the world and increasingly relies on foreign foundry and supplier sources for ICs used within its systems. Given the relatively low consumption, the U.S. military IC requirements are not a factor that can influence IC production or the assurance that parts are delivered as specified. With the majority of ICs used in modern military systems fabricated offshore, this situation presents a potential future risk that the parts acquired will not operate only in the specified manner. The objective of the Integrity and Reliability of Integrated CircuitS (IRIS) program is to develop the technology to derive the functionality of an IC to determine unambiguously if malicious modifications have been made to that IC, and to accurately determine the IC's useful lifespan from a physical perspective. The IRIS program will develop nondestructive scientifically based techniques for full functionality identification and functionality modification detection for ICs utilized in military systems. In addition, the IRIS program will develop innovative test technologies and processes that can determine an IC's useful lifespan based on a significantly reduced number of samples. Once developed, the resulting technologies may be deployed to Government or appropriate organizations that can provide critical IC functionality and reliability inspection services to the DoD, thereby ensuring that a scientific means is available to determine functionality and reliability in the various ICs deployed in DoD systems.

FY 2011 Accomplishments:
- Completed designs of digital IC test articles for functional derivation.
- Completed designs of mixed-signal IC test articles for functional derivation.
- Completed designs of digital and mixed-signal IC test articles for reliability studies.

FY 2012 Plans:
- Complete fabrication of digital and mixed-signal IC test articles for functional derivation and reliability studies.
- Complete definition of functional requirements for algorithms that determine circuit functionality without prior knowledge of their underlying logic and design.
- Demonstrate functional derivation of un-altered digital and mixed-signal ICs at the 45 nm complementary metal-oxide semiconductor (CMOS) node.
- Demonstrate reliability derivation from reduced sample sizes of digital ICs at the 90 nm node and mixed-signal ICs at the 130 nm node.
- Develop tools for functional derivation from third-party Intellectual Property (IP) blocks for both Application Specific Integrated Circuits (ASICs) and Field Programmable Gate Arrays (FPGAs).

FY 2013 Plans:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrate functional derivation of modified digital and mixed-signal ICs at the 45 nm CMOS node. - Demonstrate reliability derivation from reduced sample sizes of modified ICs. - Demonstrate non-destructive techniques for reverse engineering a digital IC. - Demonstrate tools for functional derivation from third-party IP (Intellectual Property) blocks for both ASICs and FPGAs.			
Title: Cyber Fast Track* ***Description:*** *Formerly Agile Assured Computing The Cyber Fast Track program will create more flexible, responsive methods for securing computing systems that operate in challenging environments and will reduce security risk without requiring lengthy development cycles. Under Cyber Fast Track, small agile teams will work under rapid development cycles to create cyber-security applications responsive to pop-up threats identified by DoD. This is in contrast to the current commercial security paradigm of large, highly complex, security systems that add layer upon layer of functionality and that, in themselves, are difficult to maintain and are vulnerable to attack. ***FY 2011 Accomplishments:*** - Identified mechanisms to determine outdated and unnecessary system attributes used for attacks and approaches for modifying those attributes to provide a secure operating pathway. - Initiated development of techniques for mobile endpoint security and live environment testing. - Initiated development of techniques for measurement of dynamic code, detection of vulnerabilities and exploitable bugs, and cyber automation and control. ***FY 2012 Plans:*** - Refine and update pop-up threat list with CYBERCOM. - Develop tools, methods, and techniques to reduce attack surface areas. - Demonstrate tools, methods, and techniques to reduce attack surface areas. ***FY 2013 Plans:*** - Further refine and update pop-up threat list with CYBERCOM. - Broaden tools, methods, and techniques to reduce attack surface areas. - Further demonstrate tools, methods, and techniques to reduce attack surface areas. - Transition the Cyber Fast Track business model to other DoD agencies.	5.349	10.000	17.800
Title: Clean-slate design of Resilient, Adaptive, Secure Hosts (CRASH) ***Description:*** The Clean-slate design of Resilient, Adaptive, Secure Hosts (CRASH) program will develop cyber security technologies using the mechanisms of biological systems as inspiration for radically re-thinking basic hardware and system	15.000	29.000	25.000

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

designs. Higher level organisms have two distinct immune systems: the innate system is fast and deadly but is only effective against a fixed set of pathogens; the adaptive system is slower, but can learn to recognize novel pathogens. Similarly, CRASH will develop mechanisms at the hardware and operating system level that eliminate known vulnerabilities exploited by attackers. However, because novel attacks will be developed, CRASH will also develop software techniques that allow a computer system to defend itself, to maintain its capabilities, and even heal itself. Finally, biological systems show that diversity is an effective population defense; CRASH will develop techniques that make each computer system appear unique to the attacker and allow each system to change over time.

FY 2011 Accomplishments:
- Developed initial system designs and implemented prototypes of two novel tagged security processors.
- Demonstrated through formal methods, simulation, and design walkthroughs that the prototype processors mitigate the top technical vulnerabilities.
- Implemented and validated rootkit detection capability in router operating system.
- Identified vulnerability in widely used embedded devices and developed mitigation and prevention techniques.
- Demonstrated low cost automatic patch generation for vulnerable systems.
- Demonstrated capabilities to roll-back a faulty system, install a patch, and then restore current state as if fault had never been present.
- Demonstrated initial policy weaver system that rewrites a given program into one that is guaranteed to enforce a stated security policy.
- Implemented formal verification system for operating system verification that achieves scalability by merging multiple domain specific logics, each corresponding to an abstraction layer of the operating system.
- Demonstrated a novel compiler that generates distinct variant binary files for every new compilation of the source code.

FY 2012 Plans:
- Implement two complete CRASH hardware tagged security processors capable of defeating common vulnerabilities and supporting novel, provably secure prototype operating systems.
- Demonstrate full scale systems capable of detecting and recovering from penetrations.
- Verify that known technical vulnerabilities have been addressed successfully using red team methods.
- Scale automatic patch generation to more complete coverage and to work on commercial scale systems.
- Automatically synthesize, using formal methods, hundreds of variants of a single distributed protocol, each of which is automatically proven correct.
- Implement a compiler that generates thousands of unique variants of programs that are demonstrated to be robust against return oriented programming attacks.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrate web-application environment that employs information flow to produce applications with strong information confidentiality guarantees without requiring additional effort by the application developer in order to maintain the guarantees. - Transition CRASH research into one or more commercial software applications. ***FY 2013 Plans:*** - Demonstrate moving target defense with automatically constructed diverse implementations of algorithms and programs. - Implement web-based application on secure operating system and verify its resistance to attacks through heterogeneity. - Produce formally-verified operating system kernel. - Integrate CRASH tagged security processor prototypes with secure operating system, development environments for correct-by-design software, and multiple applications. - Verify system integrity with focused red-team validation. - Demonstrate roll-back and recovery on production-scale system with substantially reduced human involvement. - Demonstrate, using policy weaving, automated implementation of security policies in applications and operating systems for a broad range of security policy frameworks. - Transition CRASH research products onto commercial router for military use.			
Title: Safer Warfighter Computing (SAFER) ***Description:*** The Safer Warfighter Computing (SAFER) program is creating a technology base for assured and trustworthy Internet communications and computation, particularly in untrustworthy and adversarial environments. SAFER creates automated processes and technologies enabling military users to send and receive content on the Internet, utilizing commercially available hardware and software, in ways that avoid efforts to deny, locate, or corrupt communications. SAFER is also developing technology for performing computations on encrypted data without decrypting it first through fully homomorphic encryption and interactive, secure multi-party computation schemes. This will enable, for example, the capability to encrypt queries and to create an encrypted search result without decrypting the query. This technology will advance the ability to run programs on untrusted hardware while keeping programs, data, and results encrypted and confidential. This mitigates the important aspect of supply chain compromise. ***FY 2011 Accomplishments:*** - Developed technical approaches for improving the security of internet-based communications and computation supporting instant messaging and web search. - Demonstrated initial security, availability, encryption, and measurement capabilities. - Developed initial homomorphic encryption implementation and new data structures to support optimized implementations of fully homomorphic encryption.	13.275	20.000	24.180

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Began second generation fully homomorphic encryption algorithm development. ***FY 2012 Plans:*** - Demonstrate enhanced security and availability capabilities with order of magnitude increase in scalability and support for full web surfing in addition to existing applications. - Perform initial independent, adversarial assessment of effectiveness of SAFER technologies to prevent communication localization and detection. - Continue development of decoy routing to support unblockable connectivity short of complete disconnection from the Internet. - Implement rich policy support for onion routing to enhance anonymity in the face of compromised routers. - Perform initial, independent benchmarks of fully homomorphic encryption, garbled-circuit secure multiparty computation, and secret-sharing secure multiparty computation. - Design program-wide application programming interfaces (APIs) for low level mathematics and cryptography to support encrypted computation using either fully homomorphic encryption or secure multiparty computation. - Demonstrate optimized software implementations of second generation fully homomorphic encryption algorithms. ***FY 2013 Plans:*** - Perform follow up independent, adversarial assessment of effectiveness of SAFER technologies to prevent communication localization and detection, including newly developed adversarial techniques. - Demonstrate field programmable gate array implementation of fully homomorphic encryption offering order of magnitude in performance improvement over optimized software implementation. - Perform follow up, independent benchmarks of fully homomorphic encryption, garbled-circuit secure multiparty computation, and secret-sharing secure multiparty computation. - Design program-wide APIs for cryptographic protocols to support encrypted computation using either fully homomorphic encryption or secure multiparty computation. - Implement prototype for new programming language to support computation on encrypted data.			
Title: Anomaly Detection at Multiple Scales (ADAMS) ***Description:*** The Anomaly Detection at Multiple Scales (ADAMS) program will develop and apply algorithms for detecting anomalous, threat-related behavior of systems, individuals, groups/organizations, and nation-states over hours, days, months, and years. ADAMS will develop flexible, scalable and highly interactive approaches to extracting actionable information from information system log files, sensors, and other instrumentation. ***FY 2011 Accomplishments:*** - Conceptualized approaches for finding indicators of anomalous behaviors buried in petabytes of observational data. ***FY 2012 Plans:***	4.500	18.000	12.502

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Prototype a scalable, distributed architecture to correlate relevant data from heterogeneous sources over extended periods of time. - Formulate techniques for determining whether a system, individual, group/organization, or nation-state is exhibiting anomalous behavior suggestive of a threat. - Develop technologies specific to the problem of detecting malicious insiders. ***FY 2013 Plans:*** - Demonstrate the capability to identify anomalous behavior suggestive of a threat. - Quantify probabilities of detection and false alarm for anomalous behaviors from measured threat profiles. - Characterize techniques for detecting malicious insiders.			
Title: Resilient Clouds* ***Description:*** *Formerly Resilient Networks The Resilient Clouds program will create technologies to enable cloud computing systems to survive and operate through cyber attacks. Vulnerabilities found in current standalone and networked systems will be amplified in cloud computing environments. Resilient Clouds will address this by creating advanced network protocols and new approaches to computing in potentially compromised distributed environments. Particular attention will be focused on adapting defenses and allocating resources dynamically in response to attacks and compromises. Resilient Clouds will create new approaches to measuring trust, reaching consensus in compromised environments, and allocating resources in response to current threats and computational requirements. Resilient Clouds will develop new verification and control techniques for networks embedded in clouds that must function reliably in complex adversarial environments. ***FY 2012 Plans:*** - Identify algorithmic advances and protocol re-design opportunities and requirements to achieve high levels of assurance in networked/cloud computing systems. - Design new algorithms and protocols in high-assurance implementations for use in networked/cloud computing systems. - Develop techniques for presenting a diverse, changing target to attackers without impacting the usability of applications running on these systems. - Create approaches and algorithms for expanding self-monitoring hosts into a cooperative self-monitoring cloud. ***FY 2013 Plans:*** - Measure the effectiveness of new algorithms and protocols for high-assurance computing in cloud computing systems that are under attack.	-	20.000	25.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Demonstrate a cloud computing environment that produces correct, mission-relevant results when individual computing elements have been compromised. - Validate the extension of host-level monitoring and adaptation to cloud-level monitoring and adaptation.			
Title: High Assurance Cyber Military Systems* ***Description:*** *Formerly Assured Mobile Platform The High Assurance Cyber Military Systems program will develop and demonstrate the technologies required to secure mission-critical embedded computing systems. The DoD is making increasing use of networked computing in systems such as military vehicles, weapon systems, ground sensors, smartphones, personal digital assistants, and other communication devices. This dependence makes it critically important that the embedded operating system provides high levels of inherent assurance. This operating system must also integrate the computational, physical, and networking elements of the system while running on a processor with very limited size, weight, and power. Consequently, it can only devote a limited share of its computational resources to security while satisfying hard real-time constraints. Recent advances in program synthesis, formal verification techniques, low-level and domain-specific programming languages, and operating systems mean that fully verified operating systems for embedded devices may be within reach at reasonable costs. Systems that admit static verification can provide both high assurance and high performance to avoid the many dynamic checks otherwise necessary to provide high assurance. The program will develop, mature, and integrate these technologies to produce an embedded computing platform that provides a high level of assurance for mission-critical military applications. ***FY 2012 Plans:*** - Perform detailed requirements and systems engineering analyses to identify embedded devices requiring high assurance levels and a corresponding concept of operations. - Produce a high-level design for identified embedded computing platforms that provides a high level of assurance for military users. - Develop approaches to reduce the time to produce high-assurance embedded systems by leveraging existing high assurance systems, either through a modular architecture or through tool reuse. ***FY 2013 Plans:*** - Build tools to assist in the rapid creation of high-assurance embedded computing systems on a variety of architectures. - Construct a high-assurance embedded operating system for two selected embedded devices using developed tools and techniques. - Formally verify full functional correctness for selected operating systems.	-	8.250	17.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrate required security properties that follow from correctness.			
Title: Cyber Physical Assurance and Resiliency (CYPHAR) ***Description:*** Cyber-physical systems (CPSs) are physical and engineered systems that integrate computing, communication, and storage capabilities with monitoring and/or control of entities in the physical world. CPSs are at the core of all modern weapons systems, critical infrastructure, transportation, and manufacturing environments. Due to the real-time and mission-critical nature of these systems, past and present CPS designs have focused on safety and performance with little-to-no emphasis given to resilience or assurance in the context of malicious intent. This leaves these systems vulnerable to exploitation and attack. The Cyber-Physical Assurance and Resiliency (CYPHAR) program will develop the scientific foundations that enable the design and implementation of fundamentally or highly secure systems that are capable of maintaining state awareness and an accepted level of operation in the presence of CPS threats. Scientific developments will include the definition of measures, metrics, and algorithms needed to optimize the security, safety, and performance of next generation CPS designs and will also allow for the holistic assessment of current systems in a quantitative manner. This program will develop technologies to provide provably secure protection mechanisms needed to ensure the confidentiality, integrity, and availability of system resources to support the design, testing, and implementation of highly assured and resilient CPSs. ***FY 2013 Plans:*** - Define the characteristics, measures, metrics, and associated design principles needed to build highly resilient and assured cyber physical systems (such as optimal CPS sensor distribution/placement, resiliency and assurance metrics, and latency/response requirements). - Initiate the development of lightweight, provably secure, and highly integrated CPS sensors and encryption devices for detection and protection of combat systems. - Develop algorithms needed to autonomously create detection rule sets based on holistic CPS sensor readings.	-	-	9.000
Title: Rapid Planning (RP) ***Description:*** The Rapid Planning (RP) program will develop rapid planning and replanning tools based on recent mathematical advances. The program will develop tools and techniques for rapid generation and adaptation of robust plans in the presence of uncertainty, imprecision, incomplete, and contradictory data and assumptions. RP will also provide a capability for monitoring plans, providing continuous replanning capability, and plain text explanations for recommended plans. RP will invest in mathematical methods to improve optimization including new branch and bound, mixed integer programming, and sub-modularity methods; techniques for accelerated simulation where accuracy can be traded for speed; design of experiments through manifold learning and identification techniques that build upon previous DARPA programs; and develop a process that is aware of interdependencies in plans and aids planners in resolving these interdependencies.	5.000	9.169	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2011 Accomplishments: - Created overarching system architecture for rapid replanning incorporating environmental and tactical uncertainty. - Designed automated identifiers for the controlling and nuisance parameters to quickly focus attention. - Implemented techniques to predict optimal performance in an evolving non-linear environment. ***FY 2012 Plans:*** - Develop techniques for rapidly assessing the robustness of plans and create the ability for planners to quickly develop and deploy plan contingencies to address potential failure modes. - Demonstrate and assess the efficacy of the tool to rapidly create and adapt plans more accurately in a military laboratory environment.			
Title: Trusted Software ***Description:*** The Trusted Software program will meet DoD demands for reliable and robust software using technology to diagnose software for inefficiencies, design errors, redundant code, and overall software inconsistencies. Current software projects are massive, dynamic social efforts involving distributed teams of developers, marketers, and users. Without the proper tools, the software engineers create errors and redundancies providing unintended and exploitable security flaws. This program will develop specific techniques to extract information on software products, model the development environment, and integrate the models into low-level software analysis tools to provide a robust diagnostic tool for building and validating trustworthy software. ***FY 2011 Accomplishments:*** - Developed techniques for analyzing inter-application communication paths, including unintended paths that represent security vulnerabilities, between applications installed on a particular device. - Demonstrated feasibility of scaling the inter-application communication analysis techniques up to an apps marketplace in tests on open source apps. - Coordinated inter-application communication analysis results with potential users at NIST. ***FY 2012 Plans:*** - Demonstrate prototype software development modeling environment. - Compare, for selected software platforms, actual software behavior against intended behavior. - Analyze and determine causes of differences between actual and intended software behavior.	5.000	10.000	-
Title: Next Generation Core Optical Networks (CORONET) ***Description:*** The Next Generation Core Optical Networks (CORONET) program revolutionized 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. Key technical enablers that were developed in this thrust include:	6.942	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
1) network management tools that guarantee optimization of high density wavelength-division-multiplexed (WDM) optical channels; 2) creation of a new class of protocols that permit the cross-layer communications needed to support quality-of-service requirements of high-priority national defense applications; and 3) demonstration of novel concepts in applications such as distributed and network-based command and control, intelligence analysis, predictive logistics management, simulation- and scenario-enhanced decision-making support for real-time combat operations, and assured operation of critical U.S. networking functions when faced with severe physical layer attack. These network-based functions support the real-time, fast-reaction operations of senior leadership, major commands and field units. ***FY 2011 Accomplishments:*** - Continued the CORONET effort to develop the network control and management software, the CORONET network-emulation testbed and the plans for technical testing and demonstrations, and formulated the technology transition plan. - Continued to work with DISA on technical oversight and evaluation of the CORONET software development effort and associated test plan. - Identified opportunities for commercial transition as well as future integration into the DISN-Core and other DoD networks.			
Title: Intrinsically Assured Mobile Ad-Hoc Networks (IAMANET) ***Description:*** The Intrinsically Assured Mobile Ad-Hoc Network (IAMANET) program completed 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). IAMANET built upon the successes achieved in both the DQW and the DCMANET programs. IAMANET directly supports the integrity, availability, reliability, confidentiality, and safety of Mobile Ad-hoc Network (MANET) communications and data. In contrast, the dominant Internet paradigm is intrinsically insecure. For example, the Internet does not deny unauthorized traffic by default and therefore violates the principle of least privilege. In addition, there are no provisions for non-repudiation or accountability and therefore adversaries can probe for vulnerabilities with impunity because the likelihood of attributing bad behavior to an adversary is limited. Current protocols are not robust to purposely induced failures and malicious behavior, leaving entire Internet-based systems vulnerable in the case of defensive failure. IAMANET, on the other hand, uses a deny-by-default networking paradigm, allowing only identifiable authorized users to communicate on the network. While the objective transition path for IAMANET technologies is to the Services to support mobile tactical operations, the IAMANET systems are interoperable with fixed networks and may also have potential applicability to the broader DoD network architecture. ***FY 2011 Accomplishments:*** - Completed the design, development and integration of a secondary subsystem for the Microsoft Windows XP platform.	2.433	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Completed design and proof of concept development of trusted hardware components. - Integrated technologies into DoD's existing information assurance desktop security application Host Based Security Suite (HBSS) to enable widespread deployment.			
Title: Trustworthy Systems ***Description:*** The Trustworthy Systems program provided new approaches to network-based monitoring that provide maximum coverage of the network (i.e. from the NIPRNET/Internet gateway to service enclaves) with performance independent of the network's size, and with computational costs that either remain constant or decrease as the network's speed or relative size increases. The deliverable of this program provided network defense technologies with: (1) high probability of detection (Pd) of malicious traffic per attack launched and, (2) a false alarm rate of not more than one false alarm per day. This technology provided gateway-and-below network traffic monitoring approaches that scale at rates that are linear (or less) to increases in network size and transmission speeds. ***FY 2011 Accomplishments:*** - Developed and integrated test-case scenarios to be used in final product testing. - Completed final asymmetric routing pathway flow and traffic analysis algorithms and initiated integration into COTS high speed switching device to meet 40 Gbps speed thresholds. - Performed network testing of the 10 Gbps and 100 Gbps products.	5.731	-	-
Title: Cyber Insider Threat ***Description:*** The Cyber Insider Threat program is developing technologies for identifying advanced cyber threat missions that may be currently ongoing within DoD and government interest systems and networks. The program focuses on identifying ongoing adversary missions rather than a person, program, or particular piece of malware. Current cyber defenses are primarily based on network and host intrusion detection and look for "break-ins" and abnormal behavior without context. The CINDER program is building tools and techniques that apply mission templates of advanced cyber espionage onto seemingly normal internal system and network activity. Through this, CINDER will uncover ongoing advanced persistent cyber threats and espionage that exist within our own cyber environments. This work is continuing in PE 0603760E, Project CCC-04 beginning in FY 2012. ***FY 2011 Accomplishments:*** - Identified several areas of significant cyber insider threat currently not covered in existing technologies and capabilities. - Characterized templates for dimensions of activity, observables, and stages of existing compromises for cyber insider threat missions.	10.500	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Focused on software development lifecycle, virtual supply chains for embedded systems, and intelligence collection through persistent access.			
Accomplishments/Planned Programs Subtotals	109.608	178.419	170.642

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
IT-04: *LANGUAGE TRANSLATION*	55.047	67.015	64.408	-	64.408	72.521	71.248	51.248	51.248	Continuing	Continuing

A. Mission Description and Budget Item Justification

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. 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. Such tactical applications imply the need for two-way (foreign-language-to-English and English-to-foreign-language) translation. 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 strategic 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 near real-time.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Robust Automatic Translation of Speech (RATS)	17.212	20.895	8.500

Description: The Robust Automatic Transcription of Speech (RATS) program addresses conditions in which speech signals are degraded by distortion, reverberation, and/or competing conversation. Robust speech processing technologies will enable soldiers to hear or read clear English versions of what is being said in their vicinity, despite a noisy or reverberant environment. RATS technology will isolate and deliver pertinent information to the warfighter by detecting periods of speech activity and discarding silent portions, determining the language spoken, identifying the speaker, and recognizing key words in challenging environments.

FY 2011 Accomplishments:
- Adapted automatic speech recognition technologies to cope with highly degraded signals.
- Optimized new processing techniques for speech activity detection, language identification, speaker identification, and keyword spotting.
- Developed bio-inspired algorithms to enable RATS processing.
- Developed methods for detecting relevant speech segments.

FY 2012 Plans:
- Improve processing techniques for increasingly noisy environments, including speech activity detection, language identification, speaker identification, and keyword spotting.
- Train systems on field collected data and test systems in realistic environments.

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Work with transition partners. ***FY 2013 Plans:*** - Finalize processing techniques for noisy environments, including speech activity detection, language identification, speaker identification, and keyword spotting. - Conduct final test of training systems on field collected data and test systems in realistic environments. - Transition to additional customers.			
Title: Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) ***Description:*** The Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) program will develop and integrate technology to enable exploitation of foreign language, hand-written documents. This technology is crucial to the warfighter, as documents including notebooks, letters, ledgers, annotated maps, newspapers, newsletters, leaflets, pictures of graffiti, and document images captured in the field may contain extremely important time-sensitive information. The MADCAT program will address this need by producing devices that will convert such captured documents from Arabic into readable English in the field. MADCAT will substantially improve applicable technologies, in particular document analysis and optical character recognition/optical handwriting recognition. MADCAT will tightly integrate these improved technologies with translation technology and create prototypes for field trials. ***FY 2011 Accomplishments:*** - Completed the development of algorithms for interpreting different regions within a document; for predicting the syntactic structure and propositional content of text; and for removing noise from contaminated and degraded documents. - Trained and tested the technology on data collected in the field. ***FY 2012 Plans:*** - Improve translation accuracy. - Develop additional language independent and script independent technologies. ***FY 2013 Plans:*** - Transition tightly integrated technology prototypes to military and intelligence operations centers. - Train and test on larger sets of field collected data.	15.375	9.870	3.529
Title: Broad Operational Language Translation (BOLT) ***Description:*** The Broad Operational Language Translation (BOLT) program will enable communication regardless of medium (voice or text) and genre (conversation, chat, or messaging) through expansion of language translation, human-machine multimodal dialogue, and language generation capabilities. BOLT will enable warfighters and military/government personnel to readily communicate with coalition partners and local populations and will enhance intelligence through better exploitation of all	-	25.000	44.062

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**PROJECT** IT-04: *LANGUAGE TRANSLATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
language sources including messaging and conversations. The program will also enable sophisticated search of stored language information and analysis of the information by increasing the capability of machines to perform deep language comprehension. ***FY 2012 Plans:*** - Formulate approaches for automatically processing informal genres, interpreting poor pronunciation, coping with incorrect/incomplete syntax, resolving references, and correlating co-references. - Conceptualize approaches for comprehension of colloquialisms and idiomatic speech. - Create a fully annotated corpus of Arabic and Chinese web discussion groups. Annotation consists of translation, alignment of words between the source and target language, the grammatical structure of the sentences in both languages, and the function of the words in both languages. - Develop databases and tools to analyze Egyptian dialectal Arabic including the difference in morphology and grammar between dialectal Arabic and Modern Standard Arabic. - Enable machines to carry on multi-modal dialogues with humans and to comprehend concepts and generate responses in multilingual environments. - Enhance information retrieval and speech-to-speech translation through human-machine dialogue. - Implement paradigms for learning deep meanings of language including ability to recognize objects, manipulate them by complex commands, and reason over the objects, the commands and the environment. ***FY 2013 Plans:*** - Develop and optimize algorithms and software for processing dialectal Arabic despite the occurrence of poor pronunciation and incorrect/incomplete syntax. - Implement and evaluate initial approaches for resolving references and correlating co-references in informal communications. - Broaden approaches for translation of colloquialisms and idiomatic speech. - Enhance a fully annotated corpus of Arabic and Chinese messaging. - Develop databases and tools to analyze Levantine dialectal Arabic including the difference in morphology and grammar between dialectal Arabic and Modern Standard Arabic. - Demonstrate performance and initial capabilities for advanced algorithms and systems providing speech transcription, machine translation, and information retrieval emphasizing semantic techniques. - Evaluate early prototypes of human-machine dialogue systems with rich disambiguation capabilities. - Develop systems for human-human communication incorporating robust error detection and human-machine dialogue for correcting errors and clarifying ambiguities. - Develop initial prototypes for deep semantic acquisition of language by machines to recognize objects, manipulate them by complex commands, and reason over the objects, the commands and the environment.			
Title: Deep Extraction from Text (DEFT)	-	-	8.317

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: The Deep Extraction from Text (DEFT) program will enable automated extraction, processing, and inference of information from text in any application domain including technical, economic, and cultural. To accomplish this, DEFT will develop and apply formal representations for basic facts, spatial, temporal, and associative relationships, causal and process knowledge, textually entailed information, and derived relationships and correlated actions/events. DEFT inputs may be in English or in a foreign language and sources may be completely free-text or semi-structured reports, messages, documents, or data bases. DEFT will extract knowledge at scale for open source intelligence and threat analysis. Planned transition partners include the intelligence community and operational commands. ***FY 2013 Plans:*** - Develop meaning equivalence representations to relate semantically similar and equivalent texts within a document, between documents, and between documents and domain knowledge databases. - Develop methods to determine the meaning in context for words that have more than one meaning. - Design a framework to update truth values/probabilities about knowledge within and across domains. - Design methods and algorithms to infer information from multiple facts and statements. - Implement algorithms to use knowledge of the domain to answer questions and make predictions. - Develop data sets and queries for science and technology, social/cultural, and asymmetric threat domains.			
Title: Global Autonomous Language Exploitation (GALE)	19.960	11.250	-
Description: The Global Autonomous Language Exploitation (GALE) program will create an integrated product enabling automated transcription and translation of foreign speech and text with targeted information retrieval. When applied to foreign language broadcast media and web-posted content, GALE systems will enhance open-source intelligence and local/regional situational awareness by reducing the cost and effort of translation and analysis. GALE will produce a fully-mature architecture and dramatically improve transcription and translation accuracy by broader exploitation of context. GALE will develop timely alerts for commanders and warfighters. ***FY 2011 Accomplishments:*** - Achieved high accuracy translation and distillation using shallow semantics with minimal ancillary information. - Achieved translation accuracy and distillation that exceeds human performance. - Provided technology updates to military and intelligence operations centers. ***FY 2012 Plans:*** - Support incorporation of sophisticated search capabilities developed in the distillation task of GALE into selected systems. - Transition technologies to new customers in the intelligence community and operational commands.			
Title: Spoken Language Communication and Translation System for Tactical Use (TRANSTAC)	2.500	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Spoken Language Communication and Translation System for Tactical Use (TRANSTAC) program developed technologies that enable robust, spontaneous, two-way tactical speech communications between our warfighters and native speakers. The program addressed the issues surrounding the rapid deployment of new languages, especially low-resource languages and dialects. TRANSTAC leveraged existing speech translation platforms to create a rapidly deployable language tool responsive to the military's language translation needs. ***FY 2011 Accomplishments:*** - Developed simultaneous multi-lingual translation techniques. - Demonstrated a multilingual translation prototype.			
Accomplishments/Planned Programs Subtotals	55.047	67.015	64.408

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602303E: *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**PROJECT** IT-05: *CYBER TECHNOLOGY*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
IT-05: *CYBER TECHNOLOGY*	-	23.333	50.000	-	50.000	66.667	83.333	100.000	125.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Cyber Technology project supports long term national security requirements through the development and demonstration of technology to increase the security of military information systems. Over the past decade the DoD has embraced net-centric warfare to enable geographically dispersed forces to attain a high level of shared battlespace awareness that is exploited to achieve strategic, operational, and tactical objectives. This involves networking people, platforms, weapons, sensors, and decision aids to create a whole that is greater than the sum of its parts. Adversaries seek to limit this force multiplier effect through cyber attacks intended to degrade, disrupt, or deny military computing, communications, and networking systems. These cyber attacks often aim to exploit vulnerabilities and defects in military software systems. Technologies developed under the Cyber Technology project will ensure DoD cyber-capabilities survive adversary cyber attacks. Promising technologies will transition to system-level projects.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Cyber Situational Awareness (CSA)*	-	10.000	21.818

Description: *Formerly Cyber Situational Awareness and Response (CSAR)

The Cyber Situational Awareness (CSA) program will develop technologies to enable comprehensive awareness and understanding of the cyber environment as required for decision-making for cyber defensive actions. This includes intelligence preparation of the cyber battlespace, indications and warning of adversary actions, detection of attack onset, attacker identification, and cyber battle damage assessment. Cyber situational awareness is made difficult by the efforts of attackers to elude detection. Approaches to cyber situational awareness will include forensic techniques to exploit data derived from events on hosts and networks that might appear innocuous when examined in isolation but reveal patterns indicative of a threat when correlated in time and space across an enterprise. CSA will also create new graphical interfaces that enable intuitive visualization of events on hosts and networks to aid in the detection of cyber attacks. This is an area where metrics are difficult to obtain, and so CSA will extend operationally-meaningful measures such as mean-time-to-detect and false-alarm rate to estimate the efficacy of proposed schemes.

FY 2012 Plans:
- Identify events on hosts and networks having the greatest potential to provide indications and warning of cyber attack.
- Conceptualize new graphical interfaces that enable intuitive visualization of anomalous events on hosts and networks suggestive of cyber attack.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop canonical classes of cyber attacks and operationally-meaningful metrics to estimate the efficacy of cyber situational awareness schemes. ***FY 2013 Plans:*** - Develop and implement advanced analytic approaches and intuitive user interfaces that correlate and display events of interest in time and space across an enterprise to enable awareness of subtle intrusion attempts and persistent penetrations. - Assess the effectiveness of the cyber situational awareness techniques in detecting novel and established cyber-attacks. - Develop collaborative/interactive system concepts to enable warfighters to anticipate cyber effects and to develop cyber tactics, techniques, and procedures. - Develop and demonstrate automated algorithms/protocols that measure mission effectiveness and dynamically reconfigure network and computing resources to render attacks ineffective.			
Title: Cyber Camouflage, Concealment, and Deception (C3D) ***Description:*** The Cyber Camouflage, Concealment, and Deception (C3D) program will develop novel approaches for protecting cyber systems that mimic camouflage, concealment, and deception in the physical world. These will make attackers expend more resources to achieve their goals and provide an asymmetric advantage for the defender. C3D will enable the creation, deployment, management, and control of synthetic entities, objects, resources, and identities that produce uncertainties for attackers and make their task significantly more difficult, perhaps even intractable. With C3D, infrastructure and other enterprise resources such as switches, servers, and storage could be virtually replicated to confound enemy targeting. Decoy file systems could confuse attackers thereby greatly decreasing their odds for success. ***FY 2012 Plans:*** - Develop a framework for the creation, deployment, management, and control of synthetic entities, objects, resources, and identities on enterprise information systems. - Develop approaches for creating multiple plausible versions of file systems and data where provenance will be uncertain for the attacker. - Explore techniques capable of deceiving an attacker into believing they have executed a successful phishing attack when in fact they have been deceived by an intelligent synthetic user. ***FY 2013 Plans:*** - Demonstrate initial implementations of native and hosted synthetic object managers compatible with the most commonly used hypervisors and operating systems. - Develop techniques for protecting the synthetic object manager from detection or compromise by an attacker.	-	7.596	15.000
Title: Crowd Sourced Formal Verification (CSFV)*	-	5.737	13.182

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: *Formerly Crowd-Sourced Cyber in PE0601101E, Project CYS-01. The Crowd-Sourced Formal Verification (CSFV) program will develop technologies and tools to enable private citizens to participate in securing cyberspace. Private citizens already collaborate on cyber-defense through participative media dedicated to issues such as diagnosing problems on networks and remediating the effects of malware on commercial systems. CSFV will create technologies that enable crowd-sourced approaches to securing software systems through formal verification. Formal software verification is a rigorous method for proving that software has specified properties, but formal verification does not currently scale to the size of software found in modern weapon systems. CSFV will enable non-specialists to participate productively in the formal verification process by transforming formal verification problems into games that are intuitively understandable. ***FY 2012 Plans:*** - Develop approaches for mapping high-level software specifications and codes into interactive computer simulations. - Develop techniques for inferring specification and coding errors from the results of these simulations and for automatically generating the appropriate annotations. - Develop web-based infrastructure to support large scale program verification workflow. ***FY 2013 Plans:*** - Develop approaches for mapping high-level formal software verification problems into interactive computer games. - Develop techniques for inferring specification and coding errors from the solutions to these games and for automatically generating the appropriate annotations to aid formal verification. - Develop web-based infrastructure to support large scale formal software verification workflow.			
Accomplishments/Planned Programs Subtotals	-	23.333	50.000

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, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	81.796	49.365	30.424	-	30.424	24.405	24.832	15.927	15.751	Continuing	Continuing
COG-02: *COGNITIVE COMPUTING*	43.546	15.674	13.542	-	13.542	8.578	8.840	8.840	8.703	Continuing	Continuing
COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	38.250	33.691	16.882	-	16.882	15.827	15.992	7.087	7.048	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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.

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

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*

B. Program Change Summary ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013 Base**	**FY 2013 OCO**	**FY 2013 Total**
Previous President's Budget	90.143	49.365	46.424	-	46.424
Current President's Budget	81.796	49.365	30.424	-	30.424
Total Adjustments	-8.347	-	-16.000	-	-16.000
• Congressional General Reductions	-0.458	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-6.069	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.500	-			
• SBIR/STTR Transfer	-2.320	-			
• TotalOtherAdjustments	-	-	-16.000	-	-16.000

Change Summary Explanation

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

FY 2013: Decrease reflects transfer of the Detection and Computational Analysis of Psychological Signals (DCAPS) program to PE 0602115E, Biomedical Technology.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	PROJECT COG-02: *COGNITIVE COMPUTING*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
COG-02: *COGNITIVE COMPUTING*	43.546	15.674	13.542	-	13.542	8.578	8.840	8.840	8.703	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Cognitive Computing project will develop core technologies that enable computing systems to learn 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Autonomous Robotic Manipulation (ARM)	20.472	15.674	13.542
Description: The Autonomous Robotic Manipulation (ARM) program is developing advanced robotic technologies that will enable autonomous (unmanned) mobile platforms to manipulate objects without human control or intervention. A key objective is intelligent control of manipulators to independently perform subtasks over a broad range of domains of interest to the warfighter, thereby reducing operator workload, time on target, training time, bandwidth, and hardware complexity. Current manipulation systems have many limitations. For example, while they perform well in certain mission environments, they have yet to demonstrate proficiency and flexibility across multiple mission environments; they require burdensome human interaction and the full attention of the operator; and the time required to complete tasks generally exceeds military users' desires. ARM will create manipulators with a high degree of autonomy capable of serving multiple military purposes across a wide variety of application domains including, but not limited to, counter-improvised explosive device, countermine, search and rescue, weapons support, checkpoint and access control, explosive ordnance disposal, and combat casualty care (including battlefield extraction). ARM will enable autonomous manipulation systems to surpass the performance level of remote manipulation systems that are controlled directly by a human operator. ***FY 2011 Accomplishments:*** - Developed manipulation primitives for handling a variety of objects, such as opening a door lock or a satchel. - Developed kinesthetic search techniques based on tactile and haptic sensing. ***FY 2012 Plans:*** - Develop a bi-manual manipulator platform by adding a second arm to the existing manipulator system, and demonstrate operation within a larger workspace and handling of articulated objects such as pliers and scissors.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop algorithms that enable head tracking of the task objects to accelerate completion time and increase robustness to change. ***FY 2013 Plans:*** - Develop and demonstrate algorithms for autonomous grasping of complex objects, such as the handle of an ammunition box. - Develop and demonstrate algorithms for autonomous bimanual manipulation, such as zipping open a satchel bag and extracting an object.			
Title: Personalized Assistant that Learns (PAL) ***Description:*** The Personalized Assistant that Learns (PAL) program enabled intelligence in information processing systems so critical DoD systems can better support the warfighter. PAL systems have embedded learning capabilities that allow them to retain prior learned knowledge, apply this knowledge to new scenarios and ultimately provide faster and more effective assistance. Cognitive systems technologies developed in this program will be applied and demonstrated in ongoing and future Command and Control Systems programs. ***FY 2011 Accomplishments:*** - Integrated PAL technology in version Battle Command-10 (BC-10) of the U.S. Army's Command Post of the Future (CPOF), demonstrated enhanced overall effectiveness and efficiency for BC-10 users, and transitioned to numerous operational units.	11.041	-	-
Title: Foundational Learning Technology ***Description:*** The Foundational Learning Technology program developed 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. Techniques addressed diverse machine learning challenges in processing of sensory inputs, language acquisition, combinatorial algorithms, strategic analysis, planning, reasoning, and reflection. Modeling human language acquisition by associating words with the real-world entities perceived through multiple modes of sensory input enabled computers to associate real world objects and events with linguistic information and use this language facility for reasoning and planning. This enabled computers to comprehend the physical world and its linguistic representations which will constitute a building block for the development of advanced computer reasoning capabilities. ***FY 2011 Accomplishments:*** - Implemented and tested machine learning approaches on selected problems in processing of sensory inputs, language acquisition, strategic analysis, planning, reasoning, and reflection. - Developed a platform for visual and tactile input to ground concepts such as objects and actions for language learning.	8.033	-	-
Title: Biomimetic Computing	4.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	**PROJECT** COG-02: *COGNITIVE COMPUTING*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: Biomimetic Computing's goal was to develop the critical technologies necessary for the realization of a cognitive artifact comprised of biologically derived simulations of the brain embodied in a mechanical (robotic) system, which is further embedded in a physical environment. These devices represent 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 2011 Accomplishments:*** - Demonstrated an autonomous robot with a simulated neural system capable of grasping a three-dimensional object as it enters the visual field and performing a mental rotation task on visual patterns by utilizing working memory.			
Accomplishments/Planned Programs Subtotals	43.546	15.674	13.542

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	**PROJECT** COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	38.250	33.691	16.882	-	16.882	15.827	15.992	7.087	7.048	Continuing	Continuing

A. Mission Description and Budget Item Justification

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, ensured communications, and advanced informatics. 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, the use of advanced informatics will help guide user's to information most relevant to them, assist caregivers with treatment, destigmatize the psychological health process, and help alert DoD to emerging psychological health trends and crises. 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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Transformative Apps ***Description:*** Transformative Apps will create the information infrastructure required to enable mission support and tactical applications (apps) to meet the efficiency, security, and availability requirements for use on mobile military networks. Of particular importance is development of a new data synchronization architecture between the handhelds and the backend computing/ storage nodes. Additionally, appropriate middleware services and libraries will be developed to facilitate shared capabilities such as map viewing, apps management, and collection of logs, usage statistics and user feedback. Apps, together with handhelds and networks, will be tested in different training environments as well as in deployed environments. Performance and usage will be carefully tracked and user feedback collected to guide rapid enhancement of apps. The effort will create a military apps development community by reaching out to non-traditional performers and will explore new models for software acquisition based on end-user empowerment. The effort will leverage the resources, experience, and lessons-learned derived from the Tactical Ground Reporting System (TIGR). ***FY 2011 Accomplishments:*** - Developed initial set of middleware services and tools. - Developed initial tactical apps suite available on a beta repository.	15.500	16.502	16.882

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	**PROJECT** COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Deployed 500+ Android handhelds and developed 20 customized and integrated apps to users in theater and completed training. - Initiated partnership to transition the software and agile processes to Army Net Warrior baseline efforts. ***FY 2012 Plans:*** - Continue operational trial in theater. - Conduct evaluations with secure network infrastructure. - Enhance middleware and services for apps. - Demonstrate apps code screening and vetting process. - Develop tools for non-experts to create apps on smartphone platforms. ***FY 2013 Plans:*** - Integrate and test with military tactical radio networks (e.g., Wireless Network After Next). - Demonstrate interoperability with Army Joint Capability Release system on mounted platforms. - Develop and deploy the apps certification process with Army users. - Expand app library and initiate transition to program of record.			
Title: Detection and Computational Analysis of Psychological Signals (DCAPS) - Medical* ***Description:*** *Formerly Healing Heroes - Medical The Detection and Computational Analysis of Psychological Signals (DCAPS) program will develop automated information systems that identify group and individual trends indicative of post-traumatic stress disorder (PTSD) and traumatic brain injury (TBI), anomaly detection algorithms to identify emerging physical and psychological crises, and provide guided access to information and educational materials. This will complement commercial on-line resources, interactive media, and social networks that supplement traditional healthcare options but have not focused on issues specific to the warfighter. DCAPS recognizes that security and privacy are critical to user acceptance and Health Insurance Portability and Accountability Act compliance and so will incorporate strong authentication and other security mechanisms as needed to protect patient data. The program will also develop partnerships with key DoD organizations working in this area, including the Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury, the Defense Medical Research and Development Program, the Army Telemedicine & Advanced Technologies Research Center, and the National Center for TeleHealth and Technology. This effort will be funded in PE 0602115E, Biomedical Technology beginning in FY 2013. ***FY 2011 Accomplishments:*** - Developed features and a classifier framework for detecting psychological distress symptoms from on-line text-based interactions.	10.750	9.079	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	**PROJECT** COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Initiated development of a mobile device application with integrated privacy safeguards for assessing psychological health status in real-time. - Formulated a general approach to optimally combining multiple psychological health indicators using semantic techniques and Bayes nets. ***FY 2012 Plans:*** - Complete development of a mobile device psychological health application with integrated privacy safeguards. - Develop additional psychological telehealth applications that integrate multiple psychological health indicators such as so called "honest signals". - Develop plans for user trials of mobile psychological health and telehealth applications in coordination with transition partners.			
Title: Graph Understanding and Analysis for Rapid Detection - Deployed On the Ground (GUARD DOG) ***Description:*** The Graph Understanding and Analysis for Rapid Detection - Deployed On the Ground (GUARD DOG) program will develop an integrated system to provide real-time data collection and analysis of patrol-based civilian interviews and field observations to facilitate understanding of the local and regional political, social, economic, and infrastructure situation in which U.S. forces are deployed. GUARD DOG will consist of two segments: a handheld/portable digital assistant to support dismounted soldiers patrolling neighborhoods and villages; and a laptop/desktop computer system that integrates data from multiple patrols and supports battalion/brigade-level analysts. GUARD DOG will provide automated support for the collect-update-analyze-prioritize process by supporting data collection and advanced analytics to evaluate the current local/regional situation, identify gaps in the knowledge base, and generate information requirements. ***FY 2011 Accomplishments:*** - Developed fast, graph-based, information analysis algorithms that can handle large, complex data sets. - Developed new technologies and system architecture to support real-time data collection and analysis. - Developed simulation test bed to evaluate selected graph-based algorithms. ***FY 2012 Plans:*** - Optimize algorithms to run on handheld devices in the field. - Enhance algorithms to address uncertain and dynamic data. - Expand architecture to support multiple distributed users. - Design, conduct and analyze field experiments using test bed and National Training Center at Ft. Irwin and/or Joint Readiness Training Center at Ft. Polk.	10.000	8.110	-
Title: Advanced Soldier Sensor Information System and Technology (ASSIST)	2.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602304E: *COGNITIVE COMPUTING SYSTEMS*	**PROJECT** COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: The Advanced Soldier Sensor Information System and Technology (ASSIST) program developed an integrated information system that exploits soldier-worn sensors to augment the soldier's ability to capture, report, and share information in the field. This includes an integrated system using advanced technologies for processing, digitizing and analyzing information captured and collected by soldier-worn sensors. ASSIST drew heavily on the experiences and lessons learned from previous Operation Iraqi Freedom missions and other surveillance and reconnaissance missions. A baseline system demonstrated the capture of video/still images together with voice annotations and location-stamping. The advanced system demonstrated automatic identification and extraction of key objects, events, activities and scenes from soldier-collected data. ***FY 2011 Accomplishments:*** - Automated the extraction of relevant portions of feeds for indexing into the Tactical Ground Reporting system (TIGR) database. - Implemented robust operation over wireless networks of very limited bandwidth. - Developed real-time collaboration tools for dismounted soldiers. - Successfully transitioned TIGR to Army Program of Record under Program Manager, Force XXI Battle Command Brigade and Below.			
Accomplishments/Planned Programs Subtotals	38.250	33.691	16.882

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602305E: *MACHINE INTELLIGENCE*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	34.773	52.276	-	-	-	-	-	-	-	Continuing	Continuing
MCN-01: *MACHINE INTELLIGENCE*	34.773	52.276	-	-	-	-	-	-	-	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Machine Intelligence project is developing technologies that will enable computing systems to extract and encode information from dynamic and stored data, observations, and experience, and to derive new knowledge, answer questions, reach conclusions, and propose explanations. Enabling computing systems with machine intelligence is now of critical importance because sensor, information, and communication systems continuously generate and deliver data at rates beyond which humans can assimilate, understand, and act. This explosion in available data/information ("big data"), combined with the ready availability of inexpensive mass storage and ubiquitous, inexpensive, computation-on-demand, provide the foundation for entirely new machine intelligence capabilities.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	44.682	61.351	52.276	-	52.276
Current President's Budget	34.773	52.276	-	-	-
Total Adjustments	-9.909	-9.075	-52.276	-	-52.276
• Congressional General Reductions	-0.227	-			
• Congressional Directed Reductions	-	-9.075			
• Congressional Rescissions	-0.292	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-8.240	-			
• SBIR/STTR Transfer	-1.150	-			
• TotalOtherAdjustments	-	-	-52.276	-	-52.276

Change Summary Explanation

FY 2011: Decrease reflects the Section 8117 Economic Adjustment, internal below threshold reprogrammings, rescissions and the SBIR/STTR transfer.
FY 2012: Decrease reflects reduction for unsustained growth.
FY 2013: Decrease reflects the end of machine reading and visual intelligence efforts and the transfer of the Visual Media Reasoning Program to PE 0602702E, Project TT-13.

C. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Machine Reading and Reasoning Technology	20.484	24.359	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602305E: *MACHINE INTELLIGENCE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: The Machine Reading and Reasoning Technology program will develop enabling technologies to acquire, integrate, and use high performance reasoning strategies in knowledge-rich domains. Such technologies will provide DoD decision makers with rapid, relevant knowledge from a broad spectrum of sources that may be dynamic and/or inconsistent. To address the significant challenges of context, temporal information, complex belief structures, and uncertainty, new capabilities are needed to extract key information and metadata, and to exploit these via context-capable search and inference. Cognitive inference has traditionally emphasized deduction via theorem-proving and induction via statistical techniques, but abduction - also known as "inference to the best explanation"- is also likely to play a large role. ***FY 2011 Accomplishments:*** - Extended knowledge extraction capabilities of machine reading systems to acquire simple relationship information in addition to factual data. - Demonstrated generality of machine reading systems through introduction of multiple domains. - Developed knowledge extraction, representation, and reasoning capabilities to support spatial, temporal, and event reasoning. - Began developing a military transition with DoD organization focused on semantic understanding of heterogeneous knowledge sources in a targeted domain. ***FY 2012 Plans:*** - Develop capability to automatically learn reading patterns by addressing ambiguity resolution and discovering inference patterns. - Demonstrate temporal reasoning over facts and events extracted from text. - Validate scalability of machine reading systems to new domains through introduction of hidden topical domains. - Apply machine reading technology to operations of transition customer.			
Title: Mind's Eye ***Description:*** The Mind's Eye program is developing a machine-based capability to learn generative representations of action between objects in a scene, directly from visual inputs, and then to reason over those learned representations. Mind's Eye will create the perceptual and cognitive underpinnings for reasoning about the action in scenes, enabling the generation of a narrative description of the action taking place in the visual field. The technologies developed under Mind's Eye have applicability in automated ground-based surveillance systems. ***FY 2011 Accomplishments:*** - Created initial visual intelligence prototype systems and demonstrated utility for autonomous reporting by generating narrative descriptions for every video in an 8,000+ video dataset with recognition performance comparable to humans.	10.000	16.000	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602305E: *MACHINE INTELLIGENCE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Developed and optimized visual intelligence algorithms for use by smart camera systems. ***FY 2012 Plans:*** - Develop improved visual intelligence capabilities based on initial assessments and evaluate on additional relevant datasets. - Integrate visual intelligence into a prototype smart camera and perform concept demonstration.			
Title: Visual Media Reasoning (VMR)* ***Description:*** *Previously Web-Scale Information Integration The Visual Media Reasoning (VMR) program will create technologies to automate the analysis of enemy-recorded photos and videos and identify, within minutes, key information related to the content. Such identification will include the names of individuals within the image (who), the enumeration of the objects within the image and their attributes (what), and the image's geospatial location and time frame (where and when). Large data stores of enemy photos and video are available but cannot be easily leveraged by a warfighter or analyst attempting to understand a specific new image. The VMR program will enable users to gain insights rapidly through application of highly parallelized image analysis techniques that can process the imagery in massive federated image stores. VMR technology will serve as a force-multiplier by rapidly and automatically extracting tactically relevant information for the human analyst and alerting the analyst to scenes that warrant the analyst's expert attention. This effort will be funded in PE 0602702E, Project TT-13 beginning in FY 2013. ***FY 2011 Accomplishments:*** - Identified operational imagery analysis scenarios (use cases), needs, and constraints. - Conceptualized approaches for automatically analyzing enemy-recorded photos and videos. - Explored potential partnerships with DoD/IC agencies. ***FY 2012 Plans:*** - Create application programming interfaces (APIs) as the basis for an open architecture that facilitates integrating new computer vision algorithms. - Demonstrate and integrate algorithms into a single system. - Identify and quantify the desired levels of operational accuracy and performance for each of the areas: Who, What, Where and When, using feedback from the warfighter/analyst user group.	4.289	11.917	-
Accomplishments/Planned Programs Subtotals	34.773	52.276	-

D. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602305E: *MACHINE INTELLIGENCE*

E. Acquisition Strategy

N/A

F. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602383E: *BIOLOGICAL WARFARE DEFENSE*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	35.318	30.421	19.236	-	19.236	27.008	27.076	25.425	23.651	Continuing	Continuing
BW-01: *BIOLOGICAL WARFARE DEFENSE*	35.318	30.421	19.236	-	19.236	27.008	27.076	25.425	23.651	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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, collection of atmospheric trace constituents to support chemical mapping, tactical and strategic biological and chemical sensors, and integrated defensive systems. This program also includes development of a unique set of platform technologies and medical countermeasures synthesis that will dramatically decrease the timeline from military threat detection to countermeasure availability.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	32.692	30.421	62.736	-	62.736
Current President's Budget	35.318	30.421	19.236	-	19.236
Total Adjustments	2.626	-	-43.500	-	-43.500
• Congressional General Reductions	-0.166	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-0.003	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	3.636	-			
• SBIR/STTR Transfer	-0.841	-			
• TotalOtherAdjustments	-	-	-43.500	-	-43.500

Change Summary Explanation

FY 2011: Increase reflects internal below threshold reprogrammings offset by the reductions for the Section 8117 Economic Adjustment and the SBIR/STTR transfer.
FY 2013: Decrease reflects the completion of chemical reconnaissance efforts and reduced efforts in medical countermeasures.

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602383E: *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Medical Countermeasures	-	12.919	19.236
Description: To further develop an expedited medical countermeasure capability, emerging technologies will be integrated to address the safety and efficacy considerations in the risk/benefit package necessary to successfully counter naturally emerging or engineered biological warfare threats and new emerging infectious threats. These technologies will also be focused on reduction of time, risk, and cost associated with new therapeutic development. ***FY 2012 Plans:*** - Begin development of in vitro tissue constructs (IVTC) that mimic the functions of human physiological systems. - Demonstrate that individual IVTCs exhibit the physiological functions normally associated with the corresponding intact human physiological system. - Design and prototype a modular platform able to sustain and monitor IVTC function. - Begin development of algorithms that will use the data obtained from the IVTC to predict drug or vaccine health effects in humans. ***FY 2013 Plans:*** - Assemble one or more IVTCs to recapitulate the function of an intact human physiological system. - Demonstrate an integrated set of IVTCs able to reproduce the function of two human physiological systems. - Demonstrate a modular platform able to sustain the integrated IVTCs for 1 week. - Demonstrate that the integrated IVTCs respond and react to test compounds in a manner that corresponds to the known effects of those compounds on human physiological systems. - Demonstrate that the modular platform can be used to predict the kinetics of metabolism and elimination that the test compounds are known to exhibit in human physiological systems. - Develop relevant functional models and technologies to identify products with therapeutic activity. - Develop new technologies to expand access to therapeutically-relevant natural products in the unexplored universe of known and unknown chemicals to expand the space for drug discovery.			
Title: Unconventional Therapeutics	16.626	7.000	-
Description: This thrust is developing unique and unconventional approaches to ensure that soldiers are protected against a wide variety of naturally occurring, indigenous or engineered threats. Past successes in this effort have come from developing therapeutics that are designed to work against broad classes of pathogens. Work in this area has also uncovered new approaches to therapeutics that, rather than attacking specific pathogens, enhance innate human immune mechanisms against broad classes of pathogens. Integral to these efforts is the development of methods that rapidly identify a broad spectrum of pathogens. Not only will these approaches be more effective against known pathogens, they also promise to offer substantial protection against unknown pathogens including engineered and emerging pathogens from third-world environments.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602383E: *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
A current emphasis is on the discovery and development of technologies that will allow a rapid response (within weeks) to unanticipated threats, whether they are naturally encountered emerging diseases or agents from intentional attack. This thrust has a goal of radically transforming the protein design process by researching and developing new mathematical and biochemical approaches to the in silico design of proteins with specific functions. This significantly decreases the time needed and increases the probability of success for biological warfare vaccine development. An additional focus 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. Select efforts funded under Unconventional Therapeutics transfer to the Medical Program Element 0602115E, in FY 2012. ***FY 2011 Accomplishments:*** - Ascertained minimal dose of vaccine necessary for antibody protection. - Completed a first-in-human FDA-approved Phase I human clinical trial to evaluate the safety (primary endpoint) and immunogenicity (secondary endpoint) of a plant-derived recombinant H1N1 vaccine candidate protein. - Demonstrated in clinical trial that two 90 Microgram (µg) doses of a plant-made H1N1 vaccine candidate is as safe and as immunogenic as one 15 µg dose of a licensed egg-based vaccine. - Demonstrated the feasibility of using the Modular Immune In Vitro Constructs (MiMIC) technology to conduct a "clinical trial in a test tube" in which the immunogenicity of a plant-derived recombinant H1N1 vaccine candidate protein was evaluated in parallel in MIMIC with the Phase I human clinical trial. - Completed one of three proof-of-concept demonstrations to produce 1kg or 10 million doses of a recombinant H1N1 vaccine candidate protein using large-scale plant-based manufacturing capabilities. - Demonstrated in pre-clinical animal studies that a plant-made H1N1 vaccine candidate formulated with standard aluminum salts adjuvant is capable of fully protecting immunized mice from a lethal H1N1 viral infection. - Developed approaches to counter pathogenic processes of any known, unknown, naturally occurring or unnaturally-evolved (engineered) pathogen. - Demonstrated various technologies that increase the median infectious dose (ID50) of a given pathogen by 10-fold compared to the untreated control ID50 in an animal model. - Demonstrated a 2-fold increase in survival time in an animal model after a high dose challenge of a given pathogen. - Demonstrated 95% survival against a first medium dose challenge of a given pathogen in an animal model using a therapy developed within 14 days of receipt of an unknown pathogen. - Demonstrated 95% three week survival after three medium dose challenges of a given pathogen in an animal model spaced 1 week apart. ***FY 2012 Plans:***			

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602383E: *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Complete remaining two proof-of-concept demonstrations to produce 1kg or 10 million doses of a recombinant H1N1 vaccine candidate protein using large-scale plant-based manufacturing capabilities. - Evaluate the immunogenicity and efficacy in pre-clinical animal studies of recombinant H1N1 vaccine candidate proteins produced in the large-scale proof-of-concept demonstration runs using large-scale plant-based manufacturing capabilities. - Demonstrate the flexibility and versatility of the plant-expressed protein platform to express human butyrylcholinesterase with pharmacokinetics and enzyme activity levels comparable to human plasma derived butyrylcholinesterase. - Conduct a first-in-human FDA-approved Phase I human clinical trial to evaluate the safety (primary endpoint) and immunogenicity (secondary endpoint) of a plant-derived recombinant H1N1 vaccine candidate protein combined with a novel oil in water emulsion as an adjuvant. - Continue the development of vaccine candidates that have enhanced immunogenicity. - Continue the development of platform technologies that shorten the time to optimal vaccine immunogenicity.			
Title: Chemical Reconnaissance ***Description:*** The Chemical Reconnaissance program will enable exhaustive, accurate, and economical collection of atmospheric trace constituents to support chemical mapping of urban and military environments. The system will demonstrate materials, packaging, and extraction technologies that sample atmospheric impurities with concentrations ranging from 10 parts per trillion to 50 parts per million by volume, from 100 liter-atmospheres of gas, in less than five minutes. The analysis system will integrate high-resolution separation and spectroscopic techniques with automated analysis software to enable identification and ranking (by concentration) of all components present in complex gas mixtures. Reproducible analysis of atmospheric samples using sophisticated analytical technology will yield data for baseline conditions, natural variability, and permit detections of nefarious anomalies associated with production, movement, and storage of weapons, even under shifting backgrounds driven by meteorological and seasonal events. ***FY 2011 Accomplishments:*** - Engineered portable prototype systems for autonomous collection on mobile and stationary platforms. - Integrated sample labeling with meteorological data, time, and geographic coordinates. - Extended accuracy and fidelity of sampling coupons. - Delivered and field tested functional sampling technology prototypes for autonomous vehicle-borne operation. - Demonstrated adsorbent manufacturing technology and economical collection. ***FY 2012 Plans:*** - Demonstrate prototype of automated analysis system with high fidelity and accuracy. - Design and validate a system to analyze a large number of samples at low cost that fits into a standard shipping container. - Integrate sample coupon processing with automated laboratory analysis system.	18.692	10.502	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602383E: *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Deliver and expand field testing of ruggedized sampling technology prototypes with transition partners.			
Accomplishments/Planned Programs Subtotals	35.318	30.421	19.236

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	205.871	202.422	233.209	-	233.209	236.851	248.447	263.251	262.912	Continuing	Continuing
TT-03: *NAVAL WARFARE TECHNOLOGY*	36.062	37.740	59.473	-	59.473	62.842	63.392	57.392	44.839	Continuing	Continuing
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	17.529	34.857	40.977	-	40.977	36.551	35.609	35.609	35.185	Continuing	Continuing
TT-06: *ADVANCED TACTICAL TECHNOLOGY*	68.304	58.539	25.797	-	25.797	26.545	29.716	50.616	70.443	Continuing	Continuing
TT-07: *AERONAUTICS TECHNOLOGY*	10.298	27.876	25.573	-	25.573	23.655	24.806	24.806	26.245	Continuing	Continuing
TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*	73.678	43.410	81.389	-	81.389	87.258	94.924	94.828	86.200	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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 unmanned sea vehicles for anti-submarine warfare.

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. Advanced manufacturing demonstration activities are also funded.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*

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 a hybrid ground/air vehicle, an advanced helicopter rotor capable of being optimized for each mission, and robust study efforts.

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, predictive modeling tools to evaluate failing nation states and identify potential hot spots, and social networking approaches to identify and track potential terrorist cells.

B. Program Change Summary ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013 Base**	**FY 2013 OCO**	**FY 2013 Total**
Previous President's Budget	224.378	206.422	217.032	-	217.032
Current President's Budget	205.871	202.422	233.209	-	233.209
Total Adjustments	-18.507	-4.000	16.177	-	16.177
• Congressional General Reductions	-2.978	-			
• Congressional Directed Reductions	-	-4.000			
• Congressional Rescissions	-19.312	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	9.510	-			
• SBIR/STTR Transfer	-5.727	-			
• TotalOtherAdjustments	-	-	16.177	-	16.177

Change Summary Explanation

FY 2011: Decrease reflects internal below threshold reprogrammings, reductions for Section 8117 Economic Adjustment, rescissions, Sec 8024(f) FFRDCs, and the SBIR/STTR transfer.
FY2012: Decrease reflects reduction to new starts.
FY 2013: Increase reflects transfer of the Visual Media Reasoning program from PE 0602305E to Project TT-13.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602702E: *TACTICAL TECHNOLOGY*	PROJECT TT-03: *NAVAL WARFARE TECHNOLOGY*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
TT-03: *NAVAL WARFARE TECHNOLOGY*	36.062	37.740	59.473	-	59.473	62.842	63.392	57.392	44.839	Continuing	Continuing

A. Mission Description and Budget Item Justification

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV)	18.941	22.740	37.798
Description: The Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV) program has three primary goals: (1) to build and demonstrate an experimental unmanned vessel with beyond state-of-the-art platform performance based on clean sheet design for unmanned operation, (2) demonstrate the technical viability of operating autonomous unmanned ships at theater or global ranges under a sparse remote supervisory control model, and (3) leverage unique ACTUV characteristics to transition a game changing ASW capability to the Navy. By establishing the premise that a human is never intended to step on board at any point in the operational cycle, ACTUV concepts can take advantage of an unexplored design space that eliminates or modifies conventional ship design constraints such as internal arrangement, reserve buoyancy, and dynamic stability in order to achieve disproportionate speed, endurance, and payload fraction. The resulting unmanned naval vessels must possess sufficient situational awareness and autonomous behavior capability to operate in full compliance with the rules of the road and maritime law to support safe navigation for operational deployments spanning thousands of miles and months of time. When coupled with innovative sensor technologies, the ACTUV system provides a low cost unmanned system with a fundamentally different operational risk calculus that enables game changing capability to detect and track even the quietest diesel electric submarine threats. Key technical areas include unmanned naval vessel design methodologies, ship system reliability, high fidelity sensor fusion to provide an accurate world model for autonomous operation, novel application of sensors for ASW tracking, and holistic system integration due to unique optimization opportunities of the ACTUV system. ***FY 2011 Accomplishments:*** - Completed multiple comprehensive integrated system concept design activities for ACTUV including supporting technology surveys, concept of operations development, preliminary operational performance assessments, and fabrication planning. - Completed sensor and autonomy risk reduction and proof of principle testing for ACTUV. - Developed ACTUV system concept of operations and conducted preliminary operational performance assessments.			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*	**PROJECT** TT-03: *NAVAL WARFARE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Integrated preliminary system performance specifications from competing system concepts into ACTUV best-of-breed system performance specification for the demonstration activity. - Completed initial Tactical Expandable Maritime Platform (TEMP) Humanitarian Assistance and Disaster Relief (HA/DR) Concept of Operations. - Refined TEMP HA/DR conceptual designs. - Completed TEMP Modular Sea Depot dry land docking testing. - Completed TEMP Modular Sea Depot in-water propulsion testing. ***FY 2012 Plans:*** - Initiate ACTUV integrated prototype detailed design, fabrication, and demonstration activity. - Conduct incremental demonstrations of ACTUV critical enabling technologies. - Commence development of ACTUV surrogate hardware-in-the-loop system. - Complete ACTUV concept of operations and preliminary operational performance assessments including situational awareness sensor performance, sonar sensor performance, and autonomous control architectures. ***FY 2013 Plans:*** - Complete ACTUV detailed design and conduct critical design review. - Perform demonstrations of ACTUV critical enabling technologies. - Conduct integrated system demonstration on ACTUV surrogate hardware-in-the-loop system. - Complete high fidelity ACTUV operational performance assessment.			
Title: Tactically Expandable Maritime Platform (TEMP) ***Description:*** The Tactically Expandable Maritime Platform (TEMP) concept, an outgrowth of the ACTUV program, seeks to develop and demonstrate macroscopic integrated systems built up from International Organization for Standardization (ISO) modular technologies that can be operated from unmodified commercial container ships and deliver credible naval capability for high priority missions. TEMP will develop critical enabling modular technologies and evaluate the feasible range of naval missions that can be serviced from this highly flexible and cost effective unconventional force structure model. An initial mission to be explored will be the modular sea depot concept to enable a remote unmonitored refueling capability for small craft; enabling independent operation from host ships. TEMP will also evaluate a Humanitarian Assistance and Disaster Relief (HA/DR) mission, engineering a modular first responder capability that allows the rapid force closure capability of TEMP to deliver immediate lifesaving operations in the hours and days following a disaster event, prior to the time that conventional platforms and organizations are able to respond. ***FY 2012 Plans:*** - Complete TEMP HA/DR critical technology risk reduction demonstrations.	-	7.000	8.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Complete TEMP HA/DR preliminary design activity and conduct a preliminary design review. - Complete TEMP Modular Sea Depot autonomy, water docking, and fuel/ballast testing. - Conduct TEMP Modular Sea Depot prototype operational demonstration. ***FY 2013 Plans:*** - Initiate TEMP HA/DR detail design, prototype development, and operational demonstration activity. - Commence TEMP HA/DR incremental risk reduction testing of critical enabling technologies, including modularized crane system, modularized air delivery vehicle, and modularized sea delivery vehicle.			
Title: Sea Change ***Description:*** Sea Change is a portfolio of disruptive approaches to critical operational challenges in the maritime domain. The goal of the Sea Change program is to develop integrated system technologies that offer fundamentally new capabilities to address long-standing operational limitations of naval forces. Sea Change focus areas include platform concepts to increase operational capability and efficiency of maritime systems and development of standoff technologies for rapid defeat of anti-access mines through a hydroacoustic anti-mine array. The hydroacoustic anti-mine array effort will explore the technical feasibility of a novel mine clearance approach using coordinated high energy density acoustic sources to deliver standoff clearance of mines throughout the water column and on the ocean bottom. By eliminating all explosive neutralizers and maintaining effectiveness with uncertain mine identification and location, the hydroacoustic anti-mine array concept has the potential to achieve dramatic reductions in area mine clearance timelines. ***FY 2012 Plans:*** - Complete concept studies and operational assessments of novel maritime propulsion approaches. - Complete proof of principle testing for hydroacoustic anti-mine array source technology. - Conduct design activity for novel propulsion system proof of principle demonstration. - Initiate hydroacoustic anti-mine array preliminary design activity and conduct developmental risk reduction testing. ***FY 2013 Plans:*** - Complete design activity for operational prototype of novel maritime propulsion approaches and hold critical design review. - Initiate fabrication and integration activity for novel maritime propulsion system operational demonstration. - Commence operational prototype design for hydroacoustic anti-mine array system technology and hold critical design review.	-	8.000	7.000
Title: Arctic Operations ***Description:*** The Arctic Operations initiative is focused on developing technology to assure U.S. capability to achieve access and situational awareness in Arctic environments. Due to retreating Arctic ice in the coming decades there is an expectation for increased shipping traffic during the summer months, and increased interest in exploiting natural resources along the Arctic	-	-	6.675

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
continental shelf. Given the unique physical challenges and stressful environmental conditions, Arctic operations today are mainly limited to expeditions requiring specialized platforms, support infrastructure, and preparation. This program will exploit unique physical attributes and emergent environmental trends in the Arctic to create surprising new capabilities, and will develop technologies for persistent and affordable sensing and communication both above and below the ice to ensure responsive operations. ***FY 2013 Plans:*** - Conduct system studies for environmentally adaptive communications, navigation and mobility. - Conduct system studies for novel under-ice and near-ice sensing, surveillance, and measurement. - Develop canonical datasets including environmental data collections to support future design studies and technology efforts.			
Title: Super-Fast Submerged Transport (Underwater Express) ***Description:*** The Super-Fast Submerged Transport (Underwater Express) program explored 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 undetected, 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 used modeling, simulation, experiments and testing to develop the understanding of the physical phenomena associated with supercavitation and the application to underwater vehicles. The program culminated in an at-sea demonstration of a scaled vehicle. ***FY 2011 Accomplishments:*** - Completed at-sea testing of a scaled vehicle. - Analyzed vehicle performance for speed, power and stability.	7.241	-	-
Title: Submersible Aircraft ***Description:*** This program combined the speed and range of an airborne platform with the stealth of an underwater vehicle by developing a vessel that can both fly and submerge. The program exploited lightweight materials, unique dynamic structures and advanced propulsion systems to overcome the technical barriers to achieving this capability. The program goals were to 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. ***FY 2011 Accomplishments:*** - Completed developmental activities including modeling and experiments, demonstrating technologies, and approaches that can overcome the identified performance objectives.	4.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Completed objective system design based on the results of developmental activities, providing an accurate projection of the systems operational envelope.			
Title: Non-traditional Active Sonar ***Description:*** The Non-traditional Active Sonar program developed alternative solutions for anti-submarine warfare active sonar. Given the trend of submarine quieting, passive sonar is of diminishing value to the Navy. The existing alternatives are high-power active sonar systems that are overt and difficult to use in peace time, especially in far forward or congested littoral areas. The program investigated new approaches which exploit special acoustic phenomena and techniques, through advanced active sonar signal processing to achieve advanced active sonar. Emphasis is on data-driven algorithm development applicable across existing Navy hydrophone sensor arrays. ***FY 2011 Accomplishments:*** - Iterated on algorithm designs to assess detection capability (for example range) and extrapolate performance to other environments and concepts of operations. - Conducted at-sea data collection with real targets, and identified existing data to support assessment of processing algorithm performance under realistic conditions. - Demonstrated processing feasibility for relevant system designs. - Documented results for use by the Navy for investigations and further research into Antisubmarine Warfare applications.	5.880	-	-
Accomplishments/Planned Programs Subtotals	36.062	37.740	59.473

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*	**PROJECT** TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	17.529	34.857	40.977	-	40.977	36.551	35.609	35.609	35.185	Continuing	Continuing

A. Mission Description and Budget Item Justification

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. This project will also explore novel design technologies for the manufacture of ground vehicles and new tools for systems assessments of emerging DARPA technologies.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Fast, Adaptable, Next Generation Ground Combat Vehicle (FANG)	-	29.961	33.977
Description: The goals of the Fast, Adaptable, Next-Generation Ground Combat Vehicle (FANG) program are to employ a novel, model-based correct-by-construction design capability, a highly-adaptable foundry-style manufacturing capability, and crowd-sourcing design methods to demonstrate 5X-10X compression in the timeline necessary to build an infantry fighting vehicle. The program seeks to create an open-source development infrastructure for the aggregation of designer inputs applicable to complex electromechanical systems as well as software, and to exercise this infrastructure with a series of design challenges, leading to prize awards and builds of winning designs in a foundry-style, rapidly configurable manufacturing facility. The design challenges will culminate in a complete build of a next generation infantry fighting vehicle to a requirements set loosely analogous to an existing program of record -but executed on a roughly one-year timescale. Additionally, the program will pursue an explicit outreach activity to high school-age students to teach the principles of model-based design and distributed foundry-style manufacturing to build a next-generation cadre of manufacturing innovators. Initial ground vehicle design work is funded under the META program in PE 0602303E, Project IT-02. ***FY 2012 Plans:*** - Complete the development and begin operational testing of the crowd-sourced vehicle design environment. - Perform experimental subsystem designs and subsequent design builds using the vehicle design environment as well as the iFAB foundry. - Promulgate component model libraries, foundry capabilities, and objective design criteria for a mobility and drivetrain challenge. - Initiate a high school outreach effort for the procurement, deployment, and utilization of a distributed additive manufacturing capability with a focus on developing the necessary software, hardware and organizational infrastructure. ***FY 2013 Plans:*** - Maintain and develop incremental upgrades to the crowd-sourced vehicle design environment.			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*	**PROJECT** TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Conduct a competitive, crowd-sourced design challenge for the mobility and drivetrain subsystem of an infantry fighting vehicle. - Promulgate component model libraries, foundry capabilities, and objective design criteria for a chassis and integrated survivability challenge. - Conduct a competitive, crowd-sourced design challenge for the chassis and survivability subsystem of an infantry fighting vehicle. - Continue the high school outreach effort by testing the developed infrastructure and running a design/build challenge involving teams from at least 10 high schools.			
Title: Avatar ***Description:*** Key advancements in telepresence and remote operation of ground systems are being made towards the ultimate goal of developing remotely operated robotic systems that can operate in dismounted environments. In order to demonstrate the utility of bi-pedal machines on real missions and accelerate their development, the synergistic partnership between machine and operator must be leveraged. The Avatar program will develop interfaces and algorithms to enable a soldier to effectively partner with a semi-autonomous bi-pedal machine and allow it to act as the soldier's surrogate. Once developed, Avatar will allow soldiers to remain out of harm's way while still leveraging their experience and strengths to complete important missions such as sentry/perimeter control, room clearing, combat casualty recovery, and, eventually, dismounted combat maneuver. Anticipated service users include the Army, Marines and Special Forces. ***FY 2013 Plans:*** - Investigate power, locomotion, perception and control of surrogate bipedal machine platforms. - Begin initial development of algorithms to allow the function of a bidirectional master controller between a human user and a remote bipedal machine. - Initiate investigations into tethered and untethered power options to allow operation over relevant mission envelopes.	-	-	7.000
Title: C-Sniper ***Description:*** 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 deliver a field testable prototype suitable for experimentation on a compatible vehicle such as the Stryker. The C-Sniper system will identify threats before they can fire. Enemy snipers may be operating both with and without telescopic sights and other optical systems in highly cluttered urban environments. The C-Sniper system will operate day and night from a static or mobile military vehicle and will provide the operator with sufficient information to make a timely engagement decision. Once a decision is made, the C-Sniper will provide data and control to point and track the on-board weapon to the selected target. The final decision to fire the weapon will be left to the operator.	7.254	4.896	-

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2011 Accomplishments: - Developed, delivered and demonstrated the operation of C-Sniper on moving vehicles. - Integrated C-Sniper on a test vehicle and demonstrated full system capability. ***FY 2012 Plans:*** - Complete demonstration of fully integrated system capabilities.			
Title: Magneto Hydrodynamic Explosive Munition (MAHEM) ***Description:*** The Magneto Hydrodynamic Explosive Munition (MAHEM) program demonstrated compressed magnetic flux generator (CMFG)-driven magneto hydrodynamically formed metal jets and self-forging penetrators (SFP) with significantly improved performance over explosively formed jets (EFJ) and fragments. MAHEM offers the potential for higher efficiency, greater control, the ability to generate and accurately time multiple jets and fragments from a single charge, and the potential for aimable, multiple warheads (multimodal warhead) with a much higher EFJ velocity, hence increased lethality precision, than conventional EFJ/SFP. ***FY 2011 Accomplishments:*** - Designed, fabricated and tested a first-of-its-kind ring initiator to be used for the multimodal warhead configuration. - Completed fabrication of Flux Compression Generator (FCG) components, shaped charge liners, and Magneto-formed penetrators (MFPs). - Performed testing of FCG components. - Tested shaped charge liners and MFPs.	1.210	-	-
Title: Crosshairs ***Description:*** The Crosshairs program developed a vehicle mounted threat detection and countermeasure system that detected, located, and engages enemy shooters against a variety of threats to include bullets, Rocket Propelled Grenades (RPGs), Anti-Tank Guided Missiles, and direct fired mortars, both stationary and on the move. Threat identification and localization is accomplished in sufficient time to enable both automatic and man-in-the-loop responses. Phase I of the program focused on initial development and testing of the Crosshairs sensor system. Phase IA culminated with a static live fire test to determine the most effective candidate sensor system. During Phase IB, enhancements were made to the sensor system for on the move performance, and on the move testing against multiple threats was conducted. DARPA and the U.S. Army Rapid Equipping Force (REF) entered into an MOA for Phase IIA. Phase IIA consisted of a moving demonstration of the hardened, packaged, and enhanced Phase I sensor system on two networked HMMWVs, integration with candidate response systems, and testing and evaluation of the complete systems in relevant environments. In Phase IIB, the Crosshairs sensor system was integrated with the Iron Curtain Active Protection System (IC-APS) on four up-armored vehicles.	3.900	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*	**PROJECT** TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
DARPA worked with the Army REF and the Project Manager Mine Resistant Ambush Protected Vehicles to validate the capabilities and initiate transition to combat forces. ***FY 2011 Accomplishments:*** - Demonstrated integrated system capability, including active protection, in live fire tests. - Transitioned Crosshairs technology to the military.			
Title: Rocket Propelled Grenade (RPG) Nets ***Description:*** The Rocket Propelled Grenade (RPG) Nets program developed a near-term counter RPG net system with 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 was supported by modeling to enhance understanding of the net interactions and with extensive live fire testing against RPGs. Successful candidates have been installed on vehicles for evaluation in an operational context. DARPA is working with the Marine Program Manager for Motor Transport to develop, test and transition this capability to combat forces. ***FY 2011 Accomplishments:*** - Completed evaluation of near-term net system and completed transition to military service.	0.900	-	-
Title: Helicopter ALert and Threat Termination (HALTT) ***Description:*** The Helicopter ALert and Threat Termination (HALTT) program provided Army and Navy/Marine helicopters with a way to detect small arms and provide shooter location to improve their ability to respond. System effectiveness with emphasis on low false alarm rates is critical. The program goal was to successfully demonstrate protection of helicopters by automatic threat detection of small arms with an "o'clock" accuracy in azimuth as well as elevation and range to shooter. ***FY 2011 Accomplishments:*** - Integrated and demonstrated acoustic system on multiple platforms. - Demonstrated a fully integrated HALTT system in-theater.	2.265	-	-
Title: Lightweight Ceramic Armor (LCA) ***Description:*** The Lightweight Ceramic Armor (LCA) program leveraged recent breakthroughs in novel ceramic fabrication processes developed in the Materials Processing Technology project to drive a dramatic performance shift in the trade-off between weight and ballistic projectile protection of body armor. Currently fielded body armor is heavy and its weight and bulk	2.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*	**PROJECT** TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
limit a soldier's agility and mobility. Utilizing recent breakthroughs in unconventional ceramics processing technology, the LCA program has demonstrated greater than ten percent reduction in weight for equal ballistic protection. ***FY 2011 Accomplishments:*** - Scaled the unconventional ceramic consolidation process to consistently produce curved ceramic plates up to specified size. - Developed the procedure (including preparation, consolidation, and cooling) to manufacture side ballistic inserts consistent with U.S. Army specifications. - Evaluated the ballistic performance of the scaled, uniquely layered armor system against multiple armor piercing threats. - Validated the capability to produce a full-size side ballistic armor insert at greater than ten percent reduction in weight as compared to current state-of-the-art solutions. - Demonstrated the capability to produce at least 10,000 ceramic plates per year.			
Accomplishments/Planned Programs Subtotals	17.529	34.857	40.977

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602702E: *TACTICAL TECHNOLOGY*	**PROJECT** TT-06: *ADVANCED TACTICAL TECHNOLOGY*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
TT-06: *ADVANCED TACTICAL TECHNOLOGY*	68.304	58.539	25.797	-	25.797	26.545	29.716	50.616	70.443	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project focuses on three 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) 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 Programs ($ in Millions)

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Excalibur	21.455	24.000	25.797
Description: The Excalibur program will develop high-power electronically-steerable optical arrays, with each array element powered by a fiber laser amplifier. These fiber-laser arrays will be sufficiently lightweight, compact, and electrically efficient to be fielded on a variety of platforms with minimal impact to the platform's original mission capabilities. Each array element will possess an adaptive-optic capability to minimize beam divergence in the presence of atmospheric turbulence, together with wide-field-of-view beam steering for target tracking. With each Excalibur array element powered by high power fiber laser amplifiers (at up to 3 kilowatts (kW) per amplifier), high power air-to-air and air-to-ground engagements will be enabled that were previously infeasible because of laser system size and weight. In addition, this program will also develop kilowatt-class arrays of diode lasers which will provide an alternate route to efficiently reaching mission-relevant power levels, and they will test the ultimate scalability of the optical phased array architecture. Excalibur arrays will be conformal to aircraft surfaces and scalable in size and power by adding elements to the array. By defending airborne platforms such as unmanned aerial vehicles against proliferated, deployed, and next-generation man-portable air-defense systems (MANPADS), Excalibur will enable these reconnaissance platforms to fly at lower altitude and obtain truly persistent, all-weather ground reconnaissance despite low-lying cloud cover. Proliferated and emerging threats will be evaluated for the potential of developing a near-term capability utilizing a single high-power fiber laser amplifier. Further capabilities include multichannel laser communications, target identification, tracking, designation, precision defeat with minimal collateral effects as well as other applications. The Excalibur Budget Activity 2 program will develop the core set of laser components for efficiently driving elements of high-power electronically steerable optical arrays, namely, high-power coherently- and spectrally-combinable fiber laser amplifiers, high-brightness laser diodes for efficiently pumping the fiber laser amplifiers, and kW-class single-mode laser diode arrays. In addition, advanced techniques (packaging, thermal and power management, beam control, target tracking, etc.) will be developed			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
for light-weight (300-500 lb), high power (3 kW - 10 kW) fiber-laser based and podded High Energy Laser Countermeasure (HELCM) systems enabling near-term options for low-altitude self-defense against MANPADS. The vulnerabilities of MANPADS and their potential to incorporate counter-countermeasures to HELCM systems will also be measured and assessed. These techniques and measurements will be designed to work in tandem with and to support the HELCM prototype subsystems developed under the Budget Activity 3 Excalibur program in PE 0603739E, Project MT-15. The Excalibur Budget Activity 2 program will also conduct several analytical studies relevant to scaling and applications of high-efficiency (30% - 40% wall plug efficient) high power electric lasers, that will examine: the potential to scale the output power of diode pumped alkali lasers (DPALs) to tactical and strategic levels (100's kW - MW class); the potential for integrating low-cost, high-sensitivity, wide-field-of-view imaging seekers and directional acoustic cueing into extended-altitude MANPADS; and the potential to use high power fiber lasers for long range target identification and tracking. ***FY 2011 Accomplishments:*** - Demonstrated a 1.6kW coherently combinable fiber laser amplifiers with an electrical efficiency exceeding 30% and near-perfect beam divergence (approximately 1.2x diffraction-limited) while developing methods to increase the combinable power to 3 kW. - Demonstrated a single laser diode bar (1 cm x 3.5 mm) with an output power of 250 W and a lifetime of greater than 100 hours on a compact low thermal-resistance (<60mK/W) heat sink. - Demonstrated a single-pass laser diode amplifier at an output greater than 1 W with linear output behavior (no perturbation instability) and no catastrophic optical damage to the facets. ***FY 2012 Plans:*** - Demonstrate 3 kW coherently combinable fiber laser amplifiers at electrical efficiencies exceeding 30% and with near-perfect beam divergence (better than 1.4x diffraction-limited). - Coherently combine five compact 100 W single-mode laser diode modules to produce a single 500 W output beam with >40% efficiency. - Demonstrate a single wavelength-stabilized laser diode bar coupled to an optical fiber (100 μm core, 0.22NA) with 300 W exiting from the fiber with a lifetime of 200 hours. - Initiate the development of advanced packaging, power storage and management, thermal management and integration techniques needed for the fabrication and testing of a 5 kg/kW high power laser subsystem and a light-weighted beam control system. - Initiate the development of advanced active target detection, confirmation and tracking techniques to support proactive threat warning and increased precision (<10 micro-radian) fine-tracking needed for HELCM systems relative to those (~milli-radians) of current DIRCM systems.			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Establish requirements and initiate design of prototype HELCM open architecture subsystems (laser, beam-control, command, threat warning/lase-quality declaration, lightweight pod). - Identify the requirements and develop the conceptual design for a proactive threat warning capability for HELCM systems. - Prepare plans and logistics for lethality testing to assess vulnerability levels and potential HEL counter-countermeasures (CCMs) of emerging MANPADS seeker technologies. ***FY 2013 Plans:*** - Complete the development of advanced packaging, power storage and management, thermal management and integration. Techniques needed for the fabrication and testing of a 5 kg/kW high power laser subsystem and a light-weight beam control system. - Continue the development of advanced active target detection, confirmation and tracking techniques to support proactive threat warning and increased precision (<10 micro-radian) fine-tracking needed for HELCM systems relative to those (~milli-radians) of current DIRCM systems. - Complete the design of prototype HELCM open architecture subsystems (laser, beam-control, command, threat warning/laser-quality declaration, lightweight pod). - Design for a proactive threat warning capability for HELCM systems. - Conduct lethality testing to establish vulnerability levels and assess the potential for incorporating HEL CCMs into emerging MANPADS seeker technologies.			
Title: High Energy Liquid Laser Area Defense System (HELLADS) ***Description:*** The goal of the High Energy Liquid Laser Area Defense System (HELLADS) program is to develop a high-energy laser weapon system (150 kW) with an order of magnitude reduction in weight compared to existing laser systems. With a weight goal of <5 kg/kW, HELLADS will enable high energy lasers (HELs) to be integrated onto tactical aircraft, and will significantly increase engagement ranges compared to ground-based systems, enabling high precision, low collateral damage, and rapid engagement of fleeting targets for both offensive and defensive missions. The HELLADS program has completed the design and demonstration of a revolutionary prototype unit cell laser module. That unit cell demonstrated power output and is demonstrating optical wavefront performance that supports the goal of a lightweight and compact 150 kW high energy tactical laser weapon system. Two unit cell module designs with integrated power and thermal management systems were fabricated and tested; they demonstrated an output power exceeding 34 kW. Based on the results of the unit cell demonstration, additional laser modules will be replicated and connected to produce a 150 kW laser that will be demonstrated in a laboratory environment. The 150 kW laser will then be integrated with beam control, prime power, thermal management, safety, and command and control subsystems all based upon existing technologies to produce a ground-based laser weapon system field demonstrator. The capability to shoot down tactical targets such as surface-to-air missiles and rockets and the capability to perform ultra-precise offensive engagements will be demonstrated in a realistic ground test environment. Additional funding for this integration effort	20.894	26.197	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
will be provided for HELLADS testing in Project NET-01, PE 0603766E. The HELLADS laser will then be transitioned to a tactical platform for performance demonstration of ground, sea, or airborne precision engagements. ***FY 2011 Accomplishments:*** - Completed unit cell performance optimization to obtain beam quality to support full system performance. - Developed advanced diagnostic tools to assess high energy laser beam quality. - Prescribed and built the active optical component to provide remaining correction of static and dynamic optical disturbances in the high energy laser. - Continued subsystem testing of the ground-based demonstrator laser weapon system. - Completed the detailed design of the 150 kW laser. - Initiated the fabrication and laboratory testing of the 150kW laser. ***FY 2012 Plans:*** - Complete the fabrication of the 150 kW laser. - Complete planning and preparations to integrate the 150 kW laser with the ground-based demonstrator laser weapon system. - Complete subsystem testing of the ground-based demonstrator laser weapon system.			
Title: Aero-Adaptive/Aero-Optic Beam Control (ABC) ***Description:*** 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 a large field-of-regard, current optical turret designs protrude into the flow. This causes severe optical 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 utility of directed energy systems 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 to synchronize the flow control system with adaptive optics. This effort will initially focus on wind tunnel testing to prove the feasibility of steady and periodic flow control techniques to reduce or regularize the large scale turbulent structures surrounding an optical turret. These tests will culminate in a hardware-in-the-loop demonstration utilizing flow control with an adaptive optics system in a full-scale wind tunnel test for the turret. Following successful wind tunnel demonstrations, a preliminary design of a flight test turret incorporating flow control will be undertaken. Completion of detailed design and fabrication will be carried on under the HELLADS program budgeted in PE 0603766E, Project NET-01. ***FY 2011 Accomplishments:*** - Performed initial testing of full-scale flow control in open-loop wind tunnel testing of ABC turret. - Demonstrated and validated ABC concept with closed-loop adaptive optic system and flow control in a full-scale wind tunnel test.	5.100	4.227	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiated preliminary design of a flight test turret incorporating flow control and optical compensation of residual distortions. ***FY 2012 Plans:*** - Complete preliminary design for mechanical surrogate turret and the flight test turret. - Identify new mission capabilities enabled by aero-effects control technology.			
Title: Polarizing Keyless Cryptography (POLKA) ***Description:*** Cryptographic security of the Department of Defense's point-to-point data links is fundamentally important and faces an emerging threat as encryption devices are rapidly out-paced by the increasing data rates of links. Building upon concepts developed under the Integrated Sensing and Processing program, the Polarizing Keyless Cryptography (POLKA) program will demonstrate a compelling all-optical encryption system that has the potential to meet the Department's needs. Traditional encryption techniques rely on mathematical algorithms implemented on electronic devices; POLKA will develop a physics-based, all-optical technique for encryption. Along with its transition partner, DARPA will analyze the theoretical and practical vulnerabilities of the POLKA system and demonstrate experimental verification of its efficacy. ***FY 2012 Plans:*** - Integrate optical encryption with Information Theoretic Security Code for secure high speed data transfer.	-	4.115	-
Title: Integrated Sensing and Processing ***Description:*** The Integrated Sensing and Processing program explored 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, encryption and information exploitation functionality in sensor systems. This program created tools that enabled 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 included 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 2011 Accomplishments:*** - Developed stochastic topological theory of non-parametric statistics. - Developed clock-free strongly open-loop controls and information state estimation for minimal-sensing in localization and navigation problems. - Developed sensors and algorithms for multi-body inspection, rendezvous and formation flight in zero gravity environments. - Developed novel optical encryption design and initiated component development.	6.370	-	-
Title: High Performance Algorithm Development	4.000	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The High Performance Algorithm Development programs identified, developed and demonstrated new mathematical paradigms to enable maximum performance at minimum cost in a variety of DoD systems applications. The programs looked 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 cultivated theoretical breakthroughs in areas of basic mathematics having relevance to emerging defense sciences and technologies. The products are typically advanced algorithms and design methodologies. 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 were developed, 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. ***FY 2011 Accomplishments:*** - Developed an Ito-style stochastic calculus to build theoretical models to improve uncertainty prediction. - Developed novel topological tools to analyze non-linear dynamical systems.			
Title: Training Superiority ***Description:*** The Training Superiority program provided new capabilities for military training by developing new approaches to increase technical competence. This includes a digital tutoring system that builds expertise through high-quality, individualized learning at a scale necessary to meet DoD requirements. Elements of the human-tutor interaction form the foundation of computer-based models that identify student motivation and memory in order to optimize learning and consolidation. The digital tutoring system replicates the methods of expert instructors and provides interactive lessons and remediation strategies based upon individual student needs. The outcome of this program was a functional prototype that is capable of IT training at a high proficiency level in reduced time, creating warfighters with superior knowledge. ***FY 2011 Accomplishments:*** - Incorporated an Exercise Framework which provides tailored student activities within the technical domain and decreases programming time of content by a factor of 10. - Created a semantic model, abstractions, and Application Program Interface that allows Socratic dialogs capable of handling a large number of semantic responses rather than a predefined set of answers. - Incorporated an extension of the Natural Language Understanding system to encompass the full range of the IT domain. This system provides the framework necessary for the digital tutor to interpret responses to open ended questions as generated by students using informal English. - Incorporated a Memory Model framework to project and target student refresh/remediation needs on a weekly, monthly and/or annual basis.	6.235	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Completed testing of eight week version of the digital tutor, showing a near five-sigma improvement in learning student outcomes.			
Title: RealWorld ***Description:*** The RealWorld program exploited 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 is scalable and distributed, a warfighter can practice by himself, in a small group, or with as many other warfighters as needed for the mission over a local or distributed network, and across all relevant platforms (dismounts, vehicles, helicopters, and fast movers). Most important is the understanding that RealWorld is not a static simulation; it is a simulation builder with applications across the spectrum of modern kinetic and non-kinetic warfare. The program created tools that allow warfighters to rapidly and easily build their own missions through the introduction of new methodology for building simulation software. This methodology and adherence to a highly modular approach has resulted in a fundamental paradigm shift in the acquisition, as well as the construction, of DoD modeling and simulation products. ***FY 2011 Accomplishments:*** - Demonstrated ability to support joint air/land/sea operations. - Created mission planning tools within the core system including a mission scripting system. - Upgraded performance to support high resolution digital imagery, 100-times greater terrain import speeds, seamless inclusion of vector-based roads, and representation of tens of thousands of buildings generated from building shapefiles. - Improved player immersion by creating character animations that support natural 1st and 3rd person views of avatars and augmented the graphic system to increase scene variation for a richer simulation experience.	4.250	-	-
Accomplishments/Planned Programs Subtotals	68.304	58.539	25.797

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
TT-07: *AERONAUTICS TECHNOLOGY*	10.298	27.876	25.573	-	25.573	23.655	24.806	24.806	26.245	Continuing	Continuing

A. Mission Description and Budget Item Justification

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Transformer (TX) Vehicle	7.000	17.500	17.960

Description: The Transformer (TX) Vehicle program will develop a vertical take-off and landing (VTOL), road-worthy vehicle that can carry a 1,000 lb payload at a range of 250 nautical miles on a single tank of fuel. With a flyable/roadable vehicle, the warfighter has the ability to avoid road obstructions as well as improvised explosive devices and ambush threats, providing flexibility for tactical military and personnel transport missions. The primary focus of this program is to demonstrate the ability to build a ground vehicle that is capable of configuring into a VTOL air vehicle that provides sufficient flight performance and range, while carrying a payload that is representative of four troops with gear. The enabling technologies of interest include hybrid electric drive, advanced batteries, stowable wing structures, ducted fan propulsion, lightweight materials, and advanced sensors and flight controls for stable transition from vertical to horizontal flight. TX vehicles could be dispatched for downed airman recovery, for evacuating injured personnel from difficult-to-access locations, or to resupply isolated small units. TX will also be suitable for enhanced company operations concepts which would provide the warfighter/team increased situational awareness for operations in an urban environment.

FY 2011 Accomplishments:
- Continued detailed trade studies to develop a vehicle design in areas including propulsion, adaptable wing structures, lightweight materials, advanced flight control system, air/ground configuration designs, and energy storage and distribution.
- Developed a detailed technology maturation plan that provides an integrated risk reduction strategy and achieves the ground and flight test goals of the demonstration prototype vehicle.
- Developed conceptual designs for the operational field vehicle.
- Developed the system requirements of a demonstration prototype vehicle.
- Successfully completed tests of key enabling propulsion related technologies.
- Conducted technology interchange meetings to develop integration plan for vehicle critical enabling technologies.

FY 2012 Plans:

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Conduct preliminary design review of TX prototype vehicle concepts to examine the prototype vehicle solutions in higher detail and the detailed program plans and cost for the remaining phases. - Integrate critical enabling technology development efforts into overall vehicle development. - Conduct component testing to show feasibility and function of key technology components. - Initiate risk reduction experiments and modeling to validate design performance. - Track traceability of the prototype vehicle to the field vehicle. ***FY 2013 Plans:*** - Conduct critical design review of TX prototype vehicle concept to ensure that it can proceed to fabrication, test, and demonstration. - Conduct component testing to show feasibility and function of key technology components. - Prepare test plans for hardware-in-the-loop testing to ensure successful integration of prototype vehicle subsystems. - Prepare test plans for ground and flight test demonstration.			
Title: Mission Adaptive Rotor (MAR) ***Description:*** The goal of the Mission Adaptive Rotor (MAR) program is to develop and demonstrate the capability to achieve dramatic improvements in rotor performance, survivability, and availability through the use of technologies that enable adaptation of the rotor throughout military missions and/or mission segments. Recent research indicates that significant performance benefits could be achieved by actively morphing the shape or properties of the rotor system; additionally, active rotors with on-blade control could eliminate the need for a rotor swashplate. MAR capability will result in dramatic improvements in system performance, operational availability, sustainability, and survivability, including reduction in acoustic susceptibility and rotor vibration while increasing useful payload fraction and range. The MAR program will mature active rotor technologies that enable the effective operation of military rotorcraft in performance-limited environments of high-altitude mountainous terrain and deserts. The MAR program will also focus on development of advanced technologies for application to future helicopter, tiltrotor, and other rotorcraft platforms and demonstrate the benefits of adaptation on a fielded system to facilitate upgrade of current multi-service rotorcraft systems. ***FY 2011 Accomplishments:*** - Defined quantitative results of design trade studies and risk mitigation assessments. - Initiated preliminary design of the MAR demonstration rotor system. - Conducted a principal investigators meeting for joint-Service and industry collaboration to identify critical enablers (tools, test facilities, specification revisions) for successful adaptive rotor development and deployment. - Defined a rotor system design for technology demonstration. - Completed objective system application development.	2.798	8.376	5.613

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Completed technology maturation plan for the MAR rotor system. - Completed systems requirement review for the MAR demonstration rotor system. ***FY 2012 Plans:*** - Perform systems requirements and mission analyses to quantify operational MAR objective rotor system capabilities. - Initiate planning for sub-scale ground testing of MAR demonstration rotor technologies. - Procure hardware in support of sub-scale ground testing of MAR demonstration rotor technologies. ***FY 2013 Plans:*** - Conduct major component risk reduction and technology maturation through bench, ground, and flight tests. - Conduct risk reduction and technology maturation of integrated rotor hub and blade assemblies at sub-scale and full scale.			
Title: Advanced Aeronautic Technologies ***Description:*** The Advanced Aeronautics Technologies program will examine and evaluate aeronautic technologies and concepts through applied research. These may include feasibility studies of novel or emergent materials, devices and tactics for both fixed and rotary wing air vehicle applications, as well as manufacturing and implementation approaches. The areas of interest range from propulsion to control techniques to solutions for aeronautic mission requirements. The result of these studies may lead to the design, development and improvement of prototypes. ***FY 2011 Accomplishments:*** - Conducted feasibility and trade studies of candidate technologies and architectures. - Performed military utility analyses of proposed tactics and concepts of operation. ***FY 2012 Plans:*** - Perform modeling of concepts and architectures. - Conduct enabling technology and sub-system feasibility experiments. ***FY 2013 Plans:*** - Continue to perform evaluation studies of emergent technologies. - Initiate conceptual designs and conduct performance trade analyses. - Conduct testing of enabling technology components.	0.500	2.000	2.000
Accomplishments/Planned Programs Subtotals	10.298	27.876	25.573

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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*	73.678	43.410	81.389	-	81.389	87.258	94.924	94.828	86.200	Continuing	Continuing

A. Mission Description and Budget Item Justification

The Network Centric Enabling Technology project develops network-centric mission applications that integrate information arising from: 1) sensors and signal/image processors; 2) collection platforms and weapon systems; 3) intelligence networks; and 4) open and other external sources. Technical challenges include the need to process huge volumes of diverse, incomplete, and uncertain data streams in tactically-relevant timeframes. Processing here includes a number of critical steps including conditioning of unstructured data, content analysis, behavioral modeling, pattern-of-life characterization, economic activity analysis, social network analysis, anomaly detection, and visualization. Operational benefits include deeper understanding of the evolving operational environment tailored to the needs of commanders at every echelon. Promising technologies are evaluated in the laboratory and demonstrated in the field to facilitate transition.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Nexus 7	26.027	30.605	35.712
Description: The Nexus 7 program applies forecasting, data extraction, and analysis methodologies to develop tools, techniques, and frameworks for the automated interpretation, quantitative analysis, and visualization of social networks. Social network theory has emerged in recent years as a promising approach for understanding groups of individuals connected through a variety of shared interests and collaborative activities. For the military, social networks provide a promising model for understanding terrorist cells, insurgent groups, and other stateless actors whose connectedness is established not on the basis of shared geography but rather through the correlation of their participation in coordinated activities such as planning meetings, training/mission rehearsal sessions, sharing of materiel/funds transfers, etc. The Nexus 7 program will develop and apply emerging methods for edge finding and cluster analysis to detect, characterize, and predict the dynamics of social networks. The resulting capabilities have important application in tactical contexts to aid analysts and operators in connecting the dots amid complex, conflicting, and incomplete data sets. They also establish a foundation for cultural intelligence - understanding the stability, governance, and economic indicators of a region - and the capability to better focus stability, security, transition, and reconstruction operations on high-payoff initiatives. The Nexus 7 program is an outgrowth of the data analysis tools explored in the Integrated Crisis Early Warning System (ICEWS) program and previous information integration work in the cognitive computing and transformative sciences areas. ***FY 2011 Accomplishments:*** - Developed and applied techniques for measuring the stability of a region from economic and other quantitative indicators. - Developed, applied, and evaluated social network analysis techniques on large-scale real-world data sets. - Created geospatial and temporal statistical algorithms and applied the algorithms to multiple data sources.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Provided intelligence, ranging from the strategic level to the tactical level, to multiple organizations in Afghanistan including Commander, International Security Assistance Force (ISAF), Commander's Initiative Group; ISAF Joint Command; and Regional Command South. ***FY 2012 Plans:*** - Develop techniques for simulation, visualization, inference, and prediction of economic and other quantitative indicators. - Develop geospatial techniques for modeling the interactions between and within cooperating/competing/conflicting social networks, sub-networks, and super-networks and for predicting the merging and splitting of social networks. - Evaluate tools and techniques on real-world social-cultural-network data. - Provide analytic quick-response reach-back capability to forward command echelons. - Transition initial suite of algorithms, software, and tools throughout DoD including Distributed Common Ground System (DCGS)-Army and NSA. ***FY 2013 Plans:*** - Provide analytic quick-response reach-back capability to forward command echelons. - Extend algorithms, tools, and methodologies to address new datasets and new formats applicable to other national security interests. - Develop techniques for obtaining timely, relevant information from social media and web-posted data streams that may be incomplete and/or inaccurate. - Transition full suite of algorithms, software, and tools throughout DoD including DCGS-Army and NSA.			
Title: Network Flow Analytics (NFA) ***Description:*** The Network Flow Analytics (NFA) program develops quantitative approaches for detecting illicit activities such as terrorist financing by monitoring flows in international financial networks. Such terrorist financing often supports drug trafficking or other criminal activities. NFA will address some of the most challenging aspects of detecting illicit money flows including correlating individual transactions that have been intentionally structured by the adversary to defy easy detection and correctly identifying the small number of illicit flows within the large background of legitimate flows. In addition, to detecting illicit activities the program will focus on the development of systems to combat corruption and ensure the integrity of networked financial systems. ***FY 2013 Plans:*** - Develop techniques for obtaining timely, relevant information from financial transaction data streams that may be incomplete and/or inaccurate. - Develop automatic data conditioning and regularization tools on terabyte scale. - Create advanced visualizations to enable humans to uncover illicit activities in large-scale datasets.	-	-	15.275

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiate transition of algorithms, tools, and methodologies.			
Title: Visual Media Reasoning (VMR)* ***Description:*** *Formerly Web-Scale Information Integration. Previously funded in PE 0602305E, Project MCN-01. The Visual Media Reasoning (VMR) program will create technologies to automate the analysis of enemy-recorded photos and videos and identify, within minutes, key information related to the content. Such identification will include the names of individuals within the image (who), the enumeration of the objects within the image and their attributes (what), and the image's geospatial location and time frame (where and when). Large data stores of enemy photos and video are available but cannot be easily leveraged by a warfighter or analyst attempting to understand a specific new image. The VMR program will enable users to gain insights rapidly through application of highly parallelized image analysis techniques that can process the imagery in massive federated image stores. VMR technology will serve as a force-multiplier by rapidly and automatically extracting tactically relevant information for the human analyst and alerting the analyst to scenes that warrant the analyst's expert attention. ***FY 2013 Plans:*** - Refine the user interface as well as the accuracy and performance of the system based on warfighter/analyst user group input. - Identify requirements and prototype a cloud-based hardware system for VMR image processing and storage of image indices. - Support the formation of expert user groups by automatically identifying individuals with related capabilities and interests.	-	-	17.102
Title: Cyber Auditable Systems (CAS) ***Description:*** The Cyber Auditable Systems (CAS) program will create the technologies necessary for the military to elicit public response and perform sentiment analysis in a secure and auditable manner over the internet. Stability, security, transition, and reconstruction operations are enhanced by the creation of democratic institutions and the elimination of systematic corruption within newly formed governments. These goals depend on the ability of users to speak freely without fear of reprisal and to participate in public referendums with privacy protections. CAS will create technology to enable safe discourse and trustworthy elections over the internet. This will require addressing all three elements of the traditional security triad - confidentiality, integrity, and availability - while also providing for new auditing mechanisms such as the capability for individuals to confirm their vote was correctly recorded and for stakeholder organizations to confirm only legitimate votes were counted. The program will expand traditional encryption algorithms and protocols to encompass auditability in systems requiring public trust. ***FY 2013 Plans:*** - Design and develop the underlying technology for an internet voting system that protects voter confidentiality, assures the integrity of the vote, and provides auditing features adequate to confirm that the results of an election are correct in relation to the votes cast.	-	-	13.300

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Perform a proof-of-concept demonstration of a prototype internet voting system.			
Title: Video and Image Retrieval and Analysis Tool (VIRAT) ***Description:*** 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 provides 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 new capability to the U.S. military and intelligence agencies. Currently, video analysis is very labor intensive, 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 final product of the VIRAT program is a system that can be transitioned to an integrated, operational military system, such as the Distributed Common Ground System (DCGS). ***FY 2011 Accomplishments:*** - Developed an approach to deal with burned-in metadata in Predator video data. - Developed efficient indexing and interactive retrieval against a larger set of activities. - Built a prototype system. - Satisfied a preliminary evaluation by Air Force Electronic Systems Center (ESC) for potential transition into the Air Force DCGS. ***FY 2012 Plans:*** - Develop technologies to accommodate stationary, ground-mounted video sources. - Add geo-registration capability to support operational use of the data. - Complete development and optimization of technologies to accommodate larger datasets. - Test and evaluate performance of the system against an experienced analyst's performance. - Complete a second phase of evaluation by Air Force ESC for potential transition into Air Force DCGS.	9.793	7.521	-
Title: Integrated Crisis Early Warning System (ICEWS) ***Description:*** 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. 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. ICEWS will also develop a collaborative, open-source testbed that will facilitate the integration and evaluation of alternative, operationally relevant social theories. Natural language processing is required to identify and extract information that is predictive from text and speech-based media and to distill that information into a form that is actionable by civilian and military leadership. ICEWS will develop a large body of test cases (source data	3.863	5.284	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
and outcomes) against which the social science theories can be evaluated. When integrated, these tools will 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 will also help commanders anticipate unintended consequences of actions taken to influence or remediate situations, consequences that may be delayed by months or years. ***FY 2011 Accomplishments:*** - Tested the ICEWS forecasting algorithms against intelligence analysts' judgment at PACOM and deployed additional ICEWS components to PACOM for test and evaluation. - Extended the ICEWS data extraction and analysis methodologies to SOUTHCOM, and deployed ICEWS components to SOUTHCOM. - Tested new unclassified data feeds from the Open Source Center for integration into ICEWS. - Experimented with state-of-the-art natural language processing methodologies to extract more accurate real time event data and other indices important for crisis forecasting. ***FY 2012 Plans:*** - Transition ICEWS components to USSTRATCOM.			
Title: Extreme Accuracy Tasked Ordnance (EXACTO) ***Description:*** The Extreme Accuracy Tasked Ordnance (EXACTO) program demonstrated the ability to engage targets at extremely long ranges, regardless of target motion or crosswinds, with previously unachievable accuracy. The EXACTO system is comprised of an advanced targeting optic, the first ever guided, power-generating, small caliber bullet, innovative guidance and control software, and a conventional sniper rifle. The EXACTO 50-caliber bullet and brass-board optical sighting technology greatly extends the day and night ranges over current state-of-the-art sniper systems allowing sniper teams to engage tactically important moving targets including accelerating vehicle-borne targets, in high crosswind conditions. EXACTO enhances survivability by allowing greater shooter standoff range and reduces target engagement timelines by a factor of 5. ***FY 2011 Accomplishments:*** - Revised component, software, and prototype system design as necessary to optimize performance. - Continued risk reduction simulation and testing of EXACTO system, component hardware and software. - Performed initial bullet packaging demonstration. - Developed detailed design and initiated fabrication of EXACTO prototype system and bullets. - Validated critical integrated sub-systems and performance models with software-in-the-loop simulations, and benchtop and live-fire tests. - Validated EXACTO system performance by incrementally demonstrating key system functionality. - Completed design and integration of brass-board targeting optic subsystem.	22.218	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Completed guidance and control software package development and debugging. - Fully integrated guidance and control software into control computer and brass-board targeting optic. - Fabricated, delivered, assembled, and integrated the first EXACTO demonstration system. - Incrementally tested and evaluated EXACTO brass-board targeting optic with prototype bullets in increasingly complex live-fire tests leading to demonstration of fully guided EXACTO bullets. - Conducted the first fully guided projectile live-fire testing at full range in representative operational environments with representative target motion.			
Title: PERsistent Stare Exploitation and Analysis System (PerSEAS) ***Description:*** The PERsistent Stare Exploitation and Analysis System (PerSEAS) program prototyped a tool to automatically and interactively identify activity-based events of interest from persistent, wide area, motion imagery data with support from signals intelligence and other sources. Persistent, wide area surveillance imagery is an ever increasing source of operational data, but exploitation of this data at present is mostly manual and requires hours to days to produce results. PerSEAS addressed the need for tools to automatically detect potentially significant adversary activities and to discriminate these from nominal background activity. Additionally, the program established prototype 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 to detect and defeat threats in real-time. ***FY 2011 Accomplishments:*** - Implemented and evaluated techniques on wide area motion imagery data. - Developed a demonstration prototype. - Refined and improved modeling techniques for normalcy modeling and anomaly detection. - Refined and improved inferencing algorithms to recognize complex chains of activities and events.	9.000	-	-
Title: Home Field ***Description:*** The Home Field program developed networked video and Laser Detection and Ranging (LADAR) processing technology to rapidly and reliably update a 3-D model of an urban area. It provided 3-D situational awareness with sufficient detail and accuracy to remove the "home field advantage" enjoyed by opponents. The Emissive Micro Displays (EMD) effort developed technologies to support the fabrication of Low-cost High pixel density Power efficient Direct emission Microdisplays (LHPDM). Current microdisplay systems use light modulation systems (liquid crystal displays, digital micromirror devices,) and by using LHPDM, it will enable the transmission of larger fractions of light from the illumination source. ***FY 2011 Accomplishments:*** - Completed demonstration of fabrication technologies that support affordable emissive microdisplays.	2.777	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated UV micro-emitter array. - Designed red, green, blue capability for EMD program displays. - Completed development and fabrication of all EMD modules.			
Accomplishments/Planned Programs Subtotals	73.678	43.410	81.389

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	278.704	219.816	166.067	-	166.067	191.363	201.316	209.963	221.828	Continuing	Continuing
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	166.249	107.592	128.444	-	128.444	145.829	153.818	158.114	171.828	Continuing	Continuing
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	112.455	49.645	37.623	-	37.623	45.534	47.498	51.849	50.000	Continuing	Continuing
MBT-03: *TACTICAL AND STRATEGIC ENERGY TECHNOLOGY*	-	62.579	-	-	-	-	-	-	-	Continuing	Continuing

A. Mission Description and Budget Item Justification

This program element is budgeted in the Applied Research Budget Activity because its objective is to develop material, biological and energy technologies that make possible a wide range of new military capabilities.

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 enable new propulsion concepts for land, sea, and space vehicles and low distortion optical lenses.

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, 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.

The Tactical and Strategic Energy Technology project is focused on the unique challenges facing the DoD in developing and demonstrating advanced power generation and energy storage technologies. It will address critical military needs for improved energy efficiency and availability to support a range of military missions that include individual warfighter and small unit operations.

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B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	312.586	237.837	253.396	-	253.396
Current President's Budget	278.704	219.816	166.067	-	166.067
Total Adjustments	-33.882	-18.021	-87.329	-	-87.329
• Congressional General Reductions	-1.564	-3.021			
• Congressional Directed Reductions	-5.000	-15.000			
• Congressional Rescissions	-15.316	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-4.085	-			
• SBIR/STTR Transfer	-7.917	-			
• TotalOtherAdjustments	-	-	-87.329	-	-87.329

Change Summary Explanation

FY 2011: Decrease reflects reductions for the Section 8117 Economic Adjustment, unsustained growth, internal below threshold reprogrammings, rescissions and the SBIR/STTR transfer.

FY 2012: Decrease reflects reductions for excessive growth and Section 8023(f) FFRDC reduction.

FY 2013: Decrease reflects the end of energy programs such as Vulcan and Tactical Advanced Power.

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	166.249	107.592	128.444	-	128.444	145.829	153.818	158.114	171.828	Continuing	Continuing

A. Mission Description and Budget Item Justification

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, low distortion optical lenses, and materials that enable new propulsion concepts for land, sea, and space vehicles.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Materials Processing and Manufacturing	14.034	9.500	17.550
Description: The Materials Processing and Manufacturing thrust is exploring new manufacturing and processing approaches that will dramatically lower the cost and decrease the time required to fabricate DoD systems. It will also develop approaches that yield new materials and materials capabilities that cannot be made through conventional processing approaches as well as address efficient, low-volume manufacturing. Included are disruptive manufacturing approaches for raw materials and components, advanced carbon fiber material and manufacturable gradient index optics. ***FY 2011 Accomplishments:*** - Initiated carbon nanotube templating as a means of alleviating nano-scale defects and enhancing carbon fiber tensile strength and modulus. - Prioritized graphene plane alignment over cross-planar bonding based on preliminary data for strength/modulus enhancement. - Started evaluation and testing by Air Force Composites Testing Lab to establish first-generation advanced carbon fiber insertion points within Air Force systems. - Demonstrated successful casting of superalloy turbine blades using ceramic molds made or produced via direct digital manufacturing. - Demonstrated fabrication of large composite wing (at the 50 ft x 10 ft scale) and a complex polymer composite structure using the out-of-the-autoclave process for High Altitude Long Endurance (HALE) prototype aircraft. - Demonstrated gradient index (GRIN) lenses in imaging and non-imaging applications such as a high-resolution imager for solid state-tracking solar concentrator. - Demonstrated expanded range and rate of refractive index gradient through new materials development or processes. - Developed and tested new metrology for GRIN materials and optics. - Produced scale to manufacturing plan including cost model and risk management plan.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiated efforts to allow access to and expand the base of manufacturing by establishing centers that enable competition of small firms and non-traditional performers with larger industry. ***FY 2012 Plans:*** - Demonstrate microstructure/property/process relationship needed for overcoming critical defect limitations in carbon fiber performance for structural applications. - Demonstrate carbon fiber with 50 percent improvement in stiffness over today's state-of-the-art high-strength structural carbon fibers. - Establish viability of fiber production process for structural carbon fiber in suitable quantities for small-lot manufacturing. - Develop rapid, robust manufacturing and processing capabilities that result in an expanded base of manufacturing, improved performance, reduced production times, and more affordable manufacturing. - Establish rapid qualification and certification methodologies to enable low-cost, high-confidence prediction of performance in actual manufactured products. ***FY 2013 Plans:*** - Demonstrate carbon fiber with 100 percent improvement in strength and 50 percent improvement in stiffness over today's state-of-the-art high-performance structure carbon fibers, at manufacturing scale. - Develop and demonstrate rapid, robust manufacture processes with an end goal of 20 percent increase in key material properties, 50 percent reduction of cost over baseline, and 50 percent reduction in time over baseline. - Establish impartial manufacturing centers of expertise that provide capability to non-traditional suppliers for demonstration, testing, and qualification of new manufacturing technologies; assist in transition to the supply chain; provide access to potential customers; and facilitate training. - Perform virtual manufacturing system exercises that pass design, manufacture, and verification of a specific part through the entire chain. - Demonstrate rapid qualification and certification methodologies that empirically optimize part qualification and employ probabilistics models for variability analysis and risk, with end goal of 50 percent reduction in certification time and cost.			
Title: Structural Materials and Coatings ***Description:*** 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 through engineered material surfaces, 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 2011 Accomplishments:*** - Demonstrated meltless titanium consolidation.	12.369	15.000	23.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated the ability to extrude bulk amorphous aluminum alloy billets from low hydrogen content powder to produce dense billets, while accurately measuring temperature rise due to adiabatic heating. - Fabricated two 24" by 96" by 12" thick multi-material beam manufacturing demonstration articles (approximately 50 percent of the weight with equivalent stiffness of a nickel aluminum bronze (NAB) beam). - Fabricated multi-material panel manufacturing demonstration articles for experimental modal analysis (2x NAB panel performance). - Developed and initiated demonstration of non-destruction evaluation techniques and associated calibration standards to detect all defects greater than 2 inches in diameter in the multi-material structures. - Continued development of the Coupling Software Environment (CSE) including the hybrid multi-material rotor (HMMR) model/domain code coupling. Developed a Beta-version of the CSE and initiated evaluation. - Performed a small-scale diagnostic flexible hydrofoil experiment in the 12" diameter water tunnel (WT) and used the measurement techniques developed to perform the steady flow rigid and flexible hydrofoil benchmark 48" diameter WT tests. ***FY 2012 Plans:*** - Demonstrate that meltless titanium alloy exhibits properties equivalent to the same conventionally processed alloy. - Demonstrate the use of digital direct manufacturing for bulk amorphous alloys for injection molding dies. - Complete testing of two 24" x 96" x 12" thick multi-material beam manufacturing demonstration articles. - Design, fabricate, and evaluate complex artifacts to determine the ability to adapt multi-material technology to complex geometries including addressing mechanical properties, structural details, modal characteristics, shock, fatigue, and dimensional controls. - Address high-risk aspects of multi-material manufacturing and testing methods to scale-up the manufacturing process to full-scale articles. - Design, fabricate, and test half artifact for experimental modal analysis to measure natural frequencies and mode shapes. - Develop plans and test methods to address critical high-risk structural details of the blade connection methods. - Continue development and initiate verification of the CSE to enable strong coupling of the HMMR domain codes required for time-accurate performance predictions of multi-material rotors. - Initiate development of customizable, adaptive, and self-indicating surfaces by modifying the mechanical, electrical, thermal, and biological interactions of surfaces with their surroundings. - Initiate development of alternative materials to replace environmentally hazardous coatings, such as chromium, currently used to prevent wear and corrosion. ***FY 2013 Plans:*** - Complete Coupling Software Environment (CSE) development and verification to enable strong coupling of the HMMR domain codes required for time-accurate performance predictions of multi-material rotors.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Complete laboratory demonstrations of materials with superior performance and extended lifetimes due to enhanced surface mechanical characteristics such as wear resistance, fracture toughness, friction, and hardness. - Manufacture and evaluate complex structural test specimens demonstrating ability to design robust products with multi-material technology. - Develop a new class of corrosion-resistant materials for a wide variety of operating environments and environmental interfaces, such as marine/air exposure. - Utilize the CSE to develop a design for a scaled multi-material propeller or rotor for testing on a large-scale vehicle. - Design full-scale propeller or rotor blades for mechanical evaluations. - Develop manufacturing process plans for large-scale vehicle and full-scale propeller or rotor blades. - Develop integrated and multi-phased sensing techniques for the determination of surface or coating integrity without damaging or removing an in-service part for inspection.			
Title: Multifunctional Materials and Structures ***Description:*** The Multifunctional Materials and Structures thrust is developing materials and structures that are explicitly tailored for multiple functions and/or unique mechanical properties. This thrust also explores novel materials and surfaces that are designed to adapt structural or functional properties to environmental and/or tactical threat conditions. Included in this thrust are efforts that will lower the weight and increase the performance of aircraft, enhance the efficiency of turbines, and improve the performance of surface dominated properties (friction, wear, and membrane permeability). New materials synthesis processes for thin films will also be explored to extend equipment lifetime and reduce logistics costs. ***FY 2011 Accomplishments:*** - Demonstrated improved ability to fabricate carbon nanotube cold cathodes towards goal of electron emission with high current densities of 50 mA/cm2 and low voltages at or below 500 V. - Designed and fabricated hardware for cold cathode/Hall effect thruster integration. - Completed designs for the ability to produce flexible cadmium telluride (CdTe) solar cells with the goal of 10 percent efficiency. - Developed hot target pulsed direct current deposition for web-based manufacturing of CdTe photovoltaics. - Designed and tested new technologies and novel membranes with high flux-transport properties that will desalinate seawater with 3x increase in flux compared to state-of-the-art desalination membranes. - Demonstrated a portable seawater desalination system that provides 30 gph potable output from synthetic seawater while requiring approximately half the energy requirement of existing fielded system. - Demonstrated the proof of concept of a human-powered, lightweight (20 lbs) desalination system with an overall power consumption of less than or equal to 5W/gph. - Continued developmental activities, including finite element modeling and shake table experiments, to validate the predicted performance of the negative stiffness structural elements for application to aircraft and high-speed maritime platforms.	20.941	9.000	9.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiated the design of an adaptive structural sub-assembly incorporating mechanical programs of tiered, negative-stiffness structural elements; activities included preliminary design and finite element modeling of the sub-assembly being used in the demonstration. ***FY 2012 Plans:*** - Design a man-powered pump to drive a desalination device enabling 75 gph potable output from seawater with an overall power consumption of less than or equal to 5W/gph. - Finalize the design and test adaptive structural sub-assemblies incorporating tiered negative stiffness structural elements; activities include final design construction and testing of adaptive structural systems. - Complete the development, construction, and testing of an adaptive structural sub-assembly that incorporates mechanical programs of tiered negative stiffness structural elements. - Exploit latest generation laser technology to enable high-temperature chemical reactions at room temperature. ***FY 2013 Plans:*** - Demonstrate a lightweight (20 lbs) desalination system that provides 75 gph potable output from seawater with an overall power consumption of less than or equal to 5W/gph. - Establish techniques to create a high flux of gas-phase reactants to a surface at ambient pressure and temperature. - Demonstrate enhanced mobility of reactant molecules on a surface layer for material growth without bulk substrate heating. - Exploit phenomena such as surface plasmon resonances to enable site-specific nucleation and growth of high-temperature coatings at room temperature.			
Title: Materials for Force Protection ***Description:*** 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 threats across the full spectrum of warfighter environments. Included in this thrust are novel topological concepts as well as entirely new structural designs that will afford enhanced protection and functionality, at reduced weight and/or cost. ***FY 2011 Accomplishments:*** - Demonstrated transparent armor based on high purity glass and ceramic formulations capable of achieving multi-hit performance at weights equivalent to that of opaque armor. - Demonstrated durability of enhanced performance transparent armor across required operating temperatures. - Demonstrated, in collaboration with the Army and Marine Corps, enhanced levels of survivability to underbody explosive blast of a lightweight (~17,000 lb) tactical vehicle configuration.	22.966	24.538	25.573

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated enhanced performance results from synergistic effects of blast mitigation technologies that include blast gas venting and vehicle cab stiffening from a structural blast channel, underbody shaping, energy absorbing floor, and energy mitigating seats incorporated into an integrated system. - Continued to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and vehicles. - Developed candidate concepts to capture kinetic energy from ballistic threats and convert it quickly into a form that can be applied to counteract the same threat. - Initiated characterization of the fundamental mechanisms and properties that control threat energy propagation and material response under dynamic loads across applicable regimes. - Initiated development of physics-based models to explicitly compute dynamic behavior of armor materials to include load paths, critical energy spreading/dissipation/conversion mechanisms, and failure modes. - Initiated development of mechanisms that can be incorporated into candidate armor material systems to manipulate ballistic energy to maximize rate of degradation without degrading material strength, at a minimum weight. - Initiated development of mechanisms that can be incorporated into candidate armor material systems that can maximize absorption, diversion, or reflection of blast energy at a minimum weight. - Developed new passive armor solutions that exploit unique high-strength/polymer composite/ceramic/glass hybrid configurations. - Began development of multifunctional passive and active hybrid systems concepts with efficient structural load support capabilities and protection within critical size, weight, and power constraints. - Assessed advanced hybrid composite technologies using low-cost materials and unique material composition and topology for incorporation into explosive reactive armor (ERA), non-explosive reactive armor (NERA), and electromagnetic armor (EMA) systems. ***FY 2012 Plans:*** - Extend the multi-hit performance capability of transparent armor at weights equivalent to that of opaque armor and its durability across the range of military operating environments (e.g., temperature, humidity, rock strike). - Continue to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and vehicles. - Conduct experimental characterization of candidate energy management integrated into armor materials across stress levels, strain rates, and impulsive loading regimes characteristic of ballistic and blast threat regimes. - Continue development and initiate validation of physics-based models to explicitly compute dynamic behavior of armor materials that incorporate essential materials properties, critical response characteristics, and relevant energy management mechanisms. - Continue development of ballistic and blast energy management mechanisms and initiate integration with material properties into candidate armor material systems for optimization against specific threats.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Apply developed high performance armor technologies to maritime platform armor concepts and adapt them for applications where traditional materials would not be appropriate for the operational environment. - Demonstrate laboratory scale synergistic passive and active armor systems for warhead defeat in multi-material configurations within critical size, weight, power, space, and cost constraints. - Optimize advanced armor solutions utilizing the ERA and NERA concepts. Test, model, and simulate target interactions to determine armor performance. ***FY 2013 Plans:*** - Scale up transparent armor solution with multi-hit performance capability of transparent armor at weights equivalent to that of opaque armor and demonstrate the ability to produce transparent armor in military relevant sizes and shapes while maintaining optical and ballistic performance characteristics. - Initiate development of capability to accurately account for and track load paths during an underbody blast event and provide material properties and energy management mechanisms to meet survivability objectives. - Continue to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and vehicles. - Perform validation testing of optimized advanced armor solutions that exploit the high-performance characteristics of low-cost materials using unique combinations of material composition and topology. - Initiate effort to identify critical parameters that will permit scaling of subscale ballistic modeling and testing into the regime of military relevance. - Develop and demonstrate the high-risk manufacturing methods to transition the advanced armor technologies from laboratory scale into large-scale manufacturing and quality control processes that provide a marinized armor solution. - Use the validated physics-based models and simulations previously developed to guide the design, development, and fabrication of ballistic and blast armor. - Continue integration of ballistic and blast energy management mechanisms into material systems and incorporate into candidate armor material systems for optimization against specific threats.			
Title: Materials for Initiation and Actuation ***Description:*** The Materials for Initiation and Actuation thrust explores and develops materials for initiation and propagation of mechanical and/or chemical effects. Included efforts are structures for meso-scale electrically initiated combustion and modulation of flame plasmas using acoustics and electrical fields. ***FY 2011 Accomplishments:*** - Extinguished a pool flame of 160 cm^2 using an acoustic field. - Extinguished an array of gas flames of 10 cm^2 total area using a hand-held electrode wand. - Determined likely mechanism and initiated modeling for electrostatic and acoustic field flame extinction.	6.230	3.000	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated both structural and energetic function in a single material composite and the ability to produce multiple samples with specified properties in sizes greater that one half pound. - Demonstrated ability to initiate energy release in a material composite that has the density of steel and a high (>100 kilopounds per square inch tensile) strength. - Demonstrated blast performance from an explosive filled reactive case of at least four times that achievable with a similar explosive charge in an inert case. ***FY 2012 Plans:*** - Identify and test approaches for scaling up electrostatic and acoustic flame suppression to address fires of 1 m^2, alone and in conjunction with conventional approaches. - Demonstrate scalability of fabrication, mechanical properties, and blast performance of high-strength reactive cases to 1 kg scale.			
Title: Reconfigurable Structures ***Description:*** In the Reconfigurable Structures thrust, new combinations of advanced materials, devices, and structural architectures are being developed to allow military platforms to move, morph, or change shape for optimal adaptation to changing mission requirements and unpredictable environments. This includes the demonstration of new materials and devices that will enable the military to function more effectively in the urban theater of operations. Another focus is to build synthetic versions of biological systems that exhibit strong reversible adhesion via van der Waals forces, magnets, or microspines to scale vertical surfaces without using ropes or ladders. In addition, this thrust will develop a more principled, scientific basis for robotic ground mobility and manipulation, and leverage these results to develop and demonstrate innovative robot design tools, fabrication methods, and control methodologies. ***FY 2011 Accomplishments:*** - Developed design parameters for scaling up gecko nanoadhesives for dynamic human climbing. - Transitioned Z-MAN prototype technologies (magnets and microspines) to initial Services clients. - Developed components of new design tools for accelerating high-quality design of robots by non-experts; to include an interactive design tool based on "functional blueprints" that automatically varied design, another design tool where user preferences served as fitness functions, and a software toolkit that handled 3-D rigid body kinematics and dynamics for any arbitrary robot. - Developed fabrication method proof-of-concept prototypes for producing robots at low cost including polyimide films for pressure sensing skin and Kevlar components to prevent punctures. - Demonstrated components of new control algorithms able to improve the mobility and manipulation performance of robots; to include a controller that moved a simulated variable-compliance arm through dense obstacles with a success rate of 95 percent	15.037	20.000	20.598

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
compared to 40 percent for a state-of-the-art planner and generation of roll and yaw instability warnings based on automatic system identification from vehicle movement. - Simulated proof-of-concept robots with higher mobility and manipulation performance than currently available including a physics-based simulation of a cheetah animal and a cheetah robot galloping at high speed. - Developed proof-of-concept components for increasing robot mobility and manipulation performance. - Designed a robot upper body with piston-driven arms and vane-actuated shoulders for a humanoid robot and developed behaviors explicitly using the arms for walking, steep climbing, and vaulting. ***FY 2012 Plans:*** - Transition additional Z-MAN prototype technologies (magnets and microspines) to initial Services clients. - Demonstrate a human static load hanging from gecko nanoadhesive. - Demonstrate that a soldier with operationally relevant equipment (250 lb upper limit) can climb 25-foot walls built from mission-relevant materials using gecko nanoadhesive. - Integrate and demonstrate components of new design tools for accelerating high-quality design of robots by non-experts, to include replacing human programming by user-guided evolution of a controller. - Create new brass board fabrication methods for producing robots at low cost, to include printing components of a walking robot. - Demonstrate new control algorithms in simulation that significantly improve performance including mobility algorithms that allow robots to locomote at least two times more efficiently and manipulation techniques that can operate in confined spaces. - Design proof-of-concept full robots with higher-performance mobility including bipeds that can walk on rough terrain, which current platforms cannot, and robots that locomote at speeds at least twice as fast as current platforms. - Explore the actuation design space and develop concepts for actuators with optimized power factor, optimized transmission, and minimized modulation loss. ***FY 2013 Plans:*** - Transition additional Z-MAN prototype sets of gecko nanoadhesive to the Services. - Apply novel design tools to reduce time of design of robots by more than 50 percent to include user-guided evolution of structures and controller, and automated morphological design processes. - Apply fabrication methods to produce robot components at substantial (> 50 percent lower) cost savings, to include printing and assembly by folding of a walking robot, and fabrication of a soft pneumatically actuated robot. - Demonstrate new control algorithms on real robots, to include mobility efficiency improvements of at least 2X, prevention of rollover by reasoning about vehicle dynamics, and a touch-sensitive arm to reach through a cluttered workspace. - Build and demonstrate robots with higher-performance mobility, including biped robots that can walk on previously inaccessible rough terrain, and robots that locomote at speeds at least twice as fast as current platforms.			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop and demonstrate optimal impedance actuators: mechanical power factor correctors; mechanical, hydraulic, and electrical approaches for lightweight, high-power, variable-ratio transmissions; and switching modulation for hydraulic actuators, stepper motors, and purely mechanical systems.			
Title: Alternate Power Sources ***Description:*** The Alternate Power Sources thrust aims to develop materials and technologies to utilize alternative power sources with the potential to provide significant strategic and tactical advantages to the DoD. A consistent DoD need continues to be greater efficiency in a portable form factor. Portable photovoltaic technologies will strive to meet this need and at low cost manufacturing. ***FY 2011 Accomplishments:*** - Developed backpack-portable PV technologies that resist heat, cold, humidity, and repeated flexure. - Demonstrated new portable PV cells that function at up to 15.5 percent power conversion efficiency and have a minimum radius of curvature of 5 cm. - Demonstrated portable PV cells that allow for low-cost manufacturing at $3.75 per Watt. - Demonstrated portable PV cells with a density of less than or equal to 2000 grams per square meter. ***FY 2012 Plans:*** - Demonstrate portable PV devices that produce at least 70 percent of their specified electrical output after one year duration and after exposure to environmental hazards such as punctures, humidity, temperature extremes, rain, and dust. - Design portable PV devices that function at greater than or equal to 20 percent power conversion efficiency. - Design PV devices that have a density of less than or equal to 1500 grams per square meter. - Design portable PV devices that have a maximum radius of curvature of 3 cm. ***FY 2013 Plans:*** - Design portable PV devices that produce at least 80 percent of their specified electrical output after one year duration and after exposure to environmental hazards such as punctures, humidity, temperature extremes, rain, and dust. - Demonstrate portable PV devices that function at greater than or equal to 20 percent power conversion efficiency. - Demonstrate portable PV devices that allow for $2 per Watt manufacturing. - Demonstrate PV devices that have density of less than or equal to 1500 grams per square meter.	11.043	6.500	5.500
Title: Functional Materials and Devices ***Description:*** The Functional Materials and Devices thrust will address problems with high performance functional materials development. Functional materials deployed for applications are most often bulk structures and performance is limited to those properties found in nature. Improved materials require deliberate control at the scale of the relevant phenomena. This thrust will	8.000	8.000	10.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
leverage the advanced fabrication capabilities currently available, coupled with design of material and structure, to drive functional materials to high performance for DoD applications by design. Novel optical materials exploiting three-dimensional degrees of freedom to increase wavefront control, and IR emissive materials are examples of near-term materials in which design of structure at the scale of the critical phenomena can have significant impact on their performance. To eliminate the intelligence surveillance and reconnaissance capability gap that currently exists at the soldier-scale, capability will be developed to provide high space/time resolution throughout the soldier-scale, space/time sphere of influence by developing task-specific functionality. These functions include hands-free zoom, automated brightness adjustment, threat detection, targeting assistance, change detection, and supplementary data overlay. This thrust will also explore newly emerging areas where structure may play an important role. ***FY 2011 Accomplishments:*** - Developed plans to improve efficiency and performance of emerging infrared optical materials. - Demonstrated modeling capabilities to predict material performance. - Designed initial contact lens binocular telescope providing hands-free, 10x, all-optical zoom, on demand. - Designed initial low-profile contact lens-based heads-up display with resolution comparable to the unaided eye. ***FY 2012 Plans:*** - Fabricate and test contact lens binocular telescope providing hands-free, 10x, all-optical zoom, on demand. - Fabricate and test low profile heads-up display with field of view and resolution comparable to the unaided eye. - Demonstrate algorithms for computer-enhanced vision in conjunction with low size, weight and power micro-cameras. ***FY 2013 Plans:*** - Demonstration and user testing of contact lens binocular telescope. - Demonstration and user testing of low profile heads-up display. - Design integrated micro-camera array to work in conjunction with low-profile head-up display.			
Title: Manufacturable Gradient Index Optics (M-GRIN) ***Description:*** Based upon technology development from the Materials Processing and Manufacturing thrust, the Manufacturable Gradient Index Optics (M-GRIN) program seeks to advance the development of GRIN lenses from a Technology Readiness Level (TRL) 3 to a Manufacturing Readiness Level (MRL) 8. The program will expand the application of gradient index optics (GRIN) by providing compact, lightweight, and cost-effective lenses with controlled dispersion and aberrations that will replace large assemblies of conventional lenses. The ability to create entirely new optical materials and surfaces creates the potential for new or significantly improved military optical applications, such as solar concentrators, portable designators, highly efficient fiber optics, and imaging systems. The program also seeks to extend GRIN manufacturing technologies to glass, ceramic, and other inorganic materials in order to allow for small, lightweight, customized optical elements for mid-wave and longwave infrared (MWIR and LWIR) applications. A key component of the program is to develop new design tools that enable optics designers to	-	12.054	17.223

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
incorporate dynamic material properties, fabrication methods, and manufacturing tolerances. The integration of new materials, design tools, and manufacturing processes will enable previously unattainable 3-D optical designs to be manufactured. This new manufacturing paradigm will enable flexible production of GRIN optics in quantities of one unit to thousands of units. ***FY 2012 Plans:*** - Develop new materials with variable index of refraction (lens tunability). - Improve materials and designs to further reduce size and weight of optical assemblies for solar concentrator and high resolution telephoto lens. - Develop new methods for controlling refractive index in thin layers of infrared (IR)-transparent materials. - Develop and demonstrate fusion and shaping of multiple layers of IR-transparent materials into lenses and characterize their optical performance. ***FY 2013 Plans:*** - Design and fabricate tunable lens from variable refractive index materials. - Establish GRIN exchange to expand materials development and share design tools. - Complete GRIN lens production scale-up from MRL-4/5 to MRL-7/8 consistent with yields of 1-1000 units as well as rapid redevelopment cycles. - Design and build prototype IR lenses using previously developed GRIN lens design tools and metrology methods.			
Title: Power Components ***Description:*** This thrust explored and developed novel components for use in diverse power systems to dramatically increase overall energy efficiency, typically with a substantial savings of weight/volume as well as cost. Included in this thrust were high energy density capacitors as well as new permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors and generators. Radically new thermoelectric architectures that allow for high efficiency in converting heat to electricity were investigated. Novel energy systems focused on immediate DoD needs such as long endurance small unmanned aerial systems, and far-future technologies to exceed the efficiency limits imposed by combustion of hydrocarbons were developed. Materials technology is also being developed to enhance power conditioning for large power applications such as Navy ships. ***FY 2011 Accomplishments:*** - Demonstrated thermoelectric nanomaterials with state-of-the-art power conversion efficiency over a wider temperature range to improve energy efficiency for ground, air, and unmanned vehicles. - Created new capacitors that provide reliable (>1500 hours continuous operating time), high-power pulsed discharges (<1 microsecond) under stress operating conditions (>125 degrees Celsius, 5kV breakdown) and possess three times the energy density than those currently available in pulse power weapon military systems and electromagnetic vehicle armor.	19.776	-	-

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated nanogap thermo-tunneling device with efficiency greater than 16 percent at a temperature difference of 350 degrees Celsius. - Completed flight tests of 8+ hour fuel-cell-enabled, long-endurance small unmanned aerial system. Began transition to user community via memorandum of agreement with Marine Corps Warfighting Laboratory. - Demonstrated path to commercially viable packaging methods of one cubic millimeter Li-ion batteries with improved energy density for potential transition to the user community. - Demonstrated viability of novel hybrid energy storage systems and down selected most promising technologies for increasing effective energy storage capacity of DoD BA-5590 battery pack form factor. - Initiated investigation of new approaches for electrochemical conversion of stored energy in carbon-based fuels to exceed the efficiency limits imposed by combustion.			
Title: Very High Efficiency Solar Cell (VHESC) ***Description:*** The Very High Efficiency Solar Cell (VHESC) program goal was to raise the system power efficiency of a new class of solar modules to forty percent and deliver engineering prototype modules that are producible. The modules use a novel optical system that splits light from the Sun into at least two different paths corresponding to the color of the light, and concentrates the light onto photovoltaic (PV) cells that cover different segments of the solar spectrum. System power efficiency includes all factors that impact the system (module) power efficiency, such as the transmission of light through the optics as well as the individual efficiencies of the PV cells. Analysis predicted that fifty percent efficiency at the PV cell level yields a system power efficiency of at least forty percent. ***FY 2011 Accomplishments:*** - Investigated effects on PV materials in high altitudes and high solar concentration environments. - Evaluated further development and improvements in solar cell technology for future DoD applications.	2.000	-	-
Title: Prognosis ***Description:*** The Prognosis thrust developed 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 were demonstrations on Navy and Air Force aircraft structures and engines for advanced jet aircraft and helicopters. Also included were sensor and model development required to support the damage prediction. ***FY 2011 Accomplishments:*** - Transitioned data sets and technology to the Air Force. Hardened and miniaturized acoustic sensors to make them suitable for flight.	5.000	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Exploited developments in acoustic emission sensor technology for rogue flaw detection in multiple aircraft critical wing zones, and demonstrated the capability to identify crack location within 1 percent of the wing zonal area. - Performed probabilistic predictions of the current and future state of aircraft wing zones using adapted fatigue models and incorporated sensor characterization; conducted model analysis based on inspection feedback. - Identified fatigue initiation and crack growth mechanisms in titanium and began development of physics-based models to characterize its microstructure and damage progression properties.			
Title: Biofuels ***Description:*** The Biofuels program explored 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 meets all DoD needs, were investigated. Initial efforts focused on the conversion of crop oil triglycerides to JP-8. Additional efforts expanded 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 that produce substantial quantities of JP-8 and other useful liquid fuels from indigenously available or harvestable resources near desired locations worldwide. ***FY 2011 Accomplishments:*** - Demonstrated system scale-up and validated cost goal. - Demonstrated technology to enable very low cost triglyceride oil from algae with competitive projected production costs of JP-8 at initial commercial scale implementation (50M gal/yr). - Demonstrated technologies to enable increasing conversion efficiency of cellulosic materials with competitive projected production costs of JP-8 at initial commercial scale implementation (50M gal/yr). - Evaluated sensitivity of biofuel cost of production in multiple locations by developing business models that take advantage of the economies of scale and shows that the technology will meet or exceed the cost goals for oil and JP-8 when extrapolated to a production scale (less than or equal to 50M gal/yr). - Investigated commercialization path to include production, co-product application, and transition to industry and DoD.	28.853	-	-
Accomplishments/Planned Programs Subtotals	166.249	107.592	128.444

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

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E. Performance Metrics

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

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	112.455	49.645	37.623	-	37.623	45.534	47.498	51.849	50.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project acknowledges the growing and pervasive influence of the biological sciences on the development of new DoD capabilities. This influence extends throughout the development of new materials, devices and processes, and relies on the integration of biological breakthroughs with those in engineering and the physical sciences. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the use of biology's unique fabrication capabilities to produce structures that cannot be made any other way, the application of materials in biological applications, and the development of manufacturing tools that use biological components and processes for materials synthesis. This project also includes major efforts aimed at integrating biological and digital sensing methodologies and maintaining human combat performance despite the extraordinary stressors of combat. Finally, this thrust will develop new diagnostics, therapeutics, and procedures to save lives on the battlefield, as well as restore full functional capabilities to combat amputees by developing a revolutionary upper limb prosthetic device. Annotated medical programs continue in FY 2012 in PE 0602115E, Project BT-01.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Maintaining Combat Performance	17.568	10.711	2.500
Description: 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 temperature extremes (-20 degrees F to 125 degrees F), oxygen deficiency at high altitude, 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 ranging from fundamental research elucidating the biological mechanisms of adaptation to application of novel body-worn actuation materials to reduce soldier loads.			
FY 2011 Accomplishments: - Determined range of effective dose for compounds to accelerate natural acclimatization at high altitudes to use as basis for dosing in combinational drug model. - Developed field-deployable, accelerated acclimatization therapeutic that includes minimal training requirements and demands on supporting infrastructure for optimal battlefield use. - Analyzed the acclimatization therapeutic's efficiency, toxicity, and pharmacokinetic information in animal studies. - Prepared Investigational New Drug (IND) application for use in an FDA Phase I clinical trial.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Studied the cause and effect of injuries within the scope of dismounted mission data. - Identified component technologies to augment soldier load in order to reduce fatigue and injuries. ***FY 2012 Plans:*** - Initiate a limited FDA Phase I clinical trial for pharmacokinetics, surrogate-efficiency markers, and tolerance to determine drug safety. - Assist in creating the Mountain Warfare Research Center for Excellence (MWRCE) at the Marine Corps Mountain Warfare Training Center, which will be sustained by support from each of the Services to facilitate high-altitude medical R&D, equipment testing, and clinical trials. - Establish baseline physiology testing at the MWRCE in support of Phase 2 clinical trials for the prevention of altitude illness. - Coordinate a technical review with major pharmaceutical companies to prepare for commercialization of the rapid altitude and hypoxia acclimatization therapeutics. - Initiate relevant core technology efforts: analysis, design, and/or benchtop testing of subsystems. - Initiate development of human and system performance analytical models (as a baseline) and system performance to assess injury mitigation strategies in a simulation environment. - Use initial output of core technology efforts to begin developing descriptions of requirements. ***FY 2013 Plans:*** - Complete altitude illness prevention clinical trials packet for review by Food and Drug Administration/Center for Drug Evaluation and Research (FDA/CDER). - Complete altitude illness treatment clinical trials packet for review by FDA/CDER. - Prepare for transition of rapid altitude and hypoxia acclimatization therapeutics and preventives to Defense Threat Reduction Agency/Transformational Medical Technologies (DTRA/TMT). - Prepare for transition of Mountain Warfare Research Center for Excellence to the Services to allow for continued testing of cold weather and high altitude equipment and therapeutics and collaboration with the U.S. Army Research Institute of Environmental Medicine (USARIEM).			
Title: Neuroscience Technologies ***Description:*** 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 warfighter'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	12.792	12.282	10.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
this impact and explore mechanisms to protect, maintain, complement, or restore cognitive functioning during and after exposure to operational stressors. In addition, new approaches for using neural signals to make human-machine systems more time efficient and less workload intense will be identified, developed, and evaluated. This project will also investigate the integration of recently characterized properties of human brain function and real-time signal processing to enable rapid triage of target-containing imagery. This thrust area will have far-reaching implications for both current and future military operations, with the potential to protect and improve cognitive performance at the individual and group level both prior to and during deployment. ***FY 2011 Accomplishments:*** - Developed brain imaging, cognitive monitoring and stimulation technologies for optimization of individual and group learning in existing military training paradigms. - Established a fast, functionally relevant, brain-based measurement of the stress response system that captures the basic features of physiological responses associated with changes in acute and chronic stress state. - Developed technologies for real-time detection of brain biochemical changes in response to stress. - Identified key molecules, pathways and anatomical connections involved in stress-related dysfunction that are amenable to behavioral and/or pharmacological interventions. - Developed methods for identifying critical stress response genes that work as part of a network of genes responsible for stress and resiliency. - Developed a new Magnetic Resonance Imaging analysis package that is currently being transferred into human clinical use. - Validated and improved optogenetic techniques as they apply to animal models of chronic stress. ***FY 2012 Plans:*** - Reconstruct a multi-scale network linked to specific stressors and stress response systems using integrated genetics, quantitative model building, bioinformatics, and computational biology approaches. - Continue modeling and verification of causal factors and relationships between variables in the complex systems and networks involved in the response to stress and the ability to resist stress. - Modulate genes and pathways mediating acute and chronic stress-induced dysfunction in circuits for reward, fear, and habit learning for reduction of stress-related dysfunction. - Develop and implement interventions for prevention of stress-induced cognitive dysfunction in animal models of acute and chronic stress. - Expand studies of stress-related dysfunction to include identifying gene, network and specific brain region dysfunction as it relates to suicide. - Transition optimization of individual and group learning technologies into standalone training platforms for military partners. ***FY 2013 Plans:*** - Integrate human data on stress genes to determine human stress-related gene networks for targeting interventions.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Determine whether choice in exercise protocol in the services can prevent stress-evoked cognitive declines. - Relate clinical and psychological profiles of patients with post-traumatic stress disorder to neural networks, neurochemicals and behavior. - Develop empirically validated intervention strategies to include stress reduction (exercise, meditation), stress inoculation (video training/therapy) and/or pharmacological interventions, while maintaining performance. - Using recent advances in information, new quantitative measures of neuro-physical performance will be defined to develop a novel warfighter training environment. - Develop biometric characterization to replace environmental characterization in order to quantify and optimize training efficacy and cohesion.			
Title: Blood Pharming ***Description:*** The 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 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, and to demonstrate a two hundred million-fold expansion of progenitor cell populations to mature RBCs. The program will capitalize advances in cell differentiation, expansion, and bioreactor technology developed early in 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. ***FY 2011 Accomplishments:*** - Demonstrated a 20x improvement in magnetic sorting using a new fabricated multi-magnet array. Bioreactor is now capable of sorting 1/10 of a unit in 24hrs; result is scalable to reach clinically relevant quantities. - Demonstrated a 30% reduction in cost per unit of RBCs. ***FY 2012 Plans:*** - Demonstrate continuous production of universal donor RBCs in a large scale bioreactor perfusion system yielding a total of 10 units of RBCs over an 8 week period. - Demonstrate a multi-fold reduction in cost per unit of RBCs by increasing the RBC cell density in the bioreactor and by reducing the media cost from $250L to $40/L to meet production goals. ***FY 2013 Plans:*** - Expand capability of bioreactor to produce plasma or other high value blood products beyond packed red blood cells.	4.245	5.250	4.100
Title: BioDesign	3.000	8.191	11.023

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: BioDesign is a new intellectual approach to biological functionality. It will employ system engineering methods in combination with biotechnology and synthetic chemical technology to create novel beneficial attributes. BioDesign mitigates the unpredictability of natural evolutionary advancement primarily by advanced genetic engineering and molecular biology technologies to produce the intended biological effect. This thrust area includes designed molecular responses that increase resistance to cellular death signals and improved computational methods for prediction of function based solely on sequence and structure of proteins produced by synthetic biological systems. Development of technologies to genetically tag and/or lock synthesized molecules would provide methods for prevention of manipulation ("tamper proof" synthetic biological systems). ***FY 2011 Accomplishments:*** - Identified mechanisms to protect unauthorized use of a research microorganism. ***FY 2012 Plans:*** - Develop genetically encoded locks to create "tamper proof" DNA. - Develop strategies to create a synthetic organism "self-destruct" option to be implemented upon unapproved removal and transport of an organism. ***FY 2013 Plans:*** - Develop novel genomic security technologies to identify microorganisms which were intentionally made resistant to antimicrobials. - Develop novel genomic circuits which identify microorganisms which were tested for virulence using live animals. - Develop strategies that time-limit production of high-value commercial microorganisms licensed for international use. - Develop lock-key recall enzyme reporting systems which resurrect event recording from proprietary microorganisms.			
Title: Living Foundries ***Description:*** The goal of Living Foundries is to create a revolutionary, biologically-based manufacturing platform to provide new materials, capabilities and manufacturing paradigms for the DoD and the Nation. The program seeks to develop the new tools, technologies and methodologies to transform biology into an engineering practice, speeding the biological design-build-test cycle and expanding the complexity of systems that can be engineered. The goal is to enable the rapid development of previously unattainable technologies and products, leveraging biology to solve challenges associated with production of new materials, novel capabilities, fuels and medicines and providing novel solutions and enhancements to military needs and capabilities. For example, one motivating, widespread and currently intractable problem is that of corrosion/materials degradation challenge that costs the DoD nearly $23 billion per year and has no near term solution in sight. Living Foundries, with its ability to truly program and engineer biology, will enable the capability to design and engineer systems to rapidly and dynamically prevent, seek out, identify and repair corrosion/materials degradation. Ultimately, Living Foundries aims to provide game-changing manufacturing paradigms for the DoD, enabling distributed, adaptable, on-demand production of critical and high-value materials, devices and	-	-	10.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
capabilities in the field or on base. Such a capability will decrease the DoD's dependence on tenuous material and energy supply chains that could be cut due to political change, targeted attack or environmental accident. Research thrusts will focus on the development and demonstration of open technology platforms, or bio-foundries, that integrate the tools and capabilities developed in PE 0601101E/TRS-01 to prove out capabilities for rapid (months vs. service-oriented architecture years) design and construction of new biological production systems. The ultimate vision is to develop point-of-use, on-demand, distributed and customized production of strategic materials and systems that exploit the capabilities and programmability (through DNA) of biology. Activities in this area will accelerate the development of DoD-focused applications and shift the field from simple, isolated genetic circuits to whole genome engineering. Such a platform spans from the ability to design, optimize and simulate (in silico) a synthetic genetic regulatory network to the automated fabrication and validation of the synthetic design in a biological system. Demonstration platforms will be challenged to build a variety of military-relevant and complex functionalities, such as the ability to withstand harsh environments, to synthesize complex mixtures of chemicals, or to rapidly and dynamically prevent, seek out, identify and repair corrosion/materials degradation. ***FY 2013 Plans:*** - Initiate integration of fundamental tools and capabilities developed in PE 0601101E/TRS-01 to speed the design, build, and test loop of biological manufacturing and start bio-foundries development. - Begin development and refinement of tools and capabilities to translate designs across multiple platforms and biological systems.			
Title: Revolutionizing Prosthetics ***Description:*** 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 and 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 re-acquire full functionality and return to military service if so desired. The advances required to provide fully functional limb replacements will be achieved by an aggressive, milestone driven program combining the talents of scientists from diverse areas including: medicine, neuroscience, orthopedics, engineering, materials science, control and information theory, mathematics, power, manufacturing, rehabilitation, psychology and training. The results of this program will radically improve the ability of combat amputees to return to normal function. This effort will be funded in PE 0602115E, Biomedical Technology beginning in FY 2013. ***FY 2011 Accomplishments:*** - Continued qualification testing and demonstrations of neural interfaces suitable for submission to FDA. - Initiated experiments to determine level of sensory stimulation that can be delivered to patients through neural interface.	11.393	10.000	-

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Designed and fabricated new neural interfaces to enable complex stimulation and control; initiated design and testing of active implantable arrays to reduce number of wires passing through surgical site. - Completed 26 clinical trials with Veterans Affairs subjects and 5 take-home trials with other subjects; applied user feedback to design of pre-production mechanical arm system. ***FY 2012 Plans:*** - Demonstrate neural control of arms by spinal cord-injured patients. - Demonstrate safety and stability of neural interfaces over multiple month periods. - Support transition efforts of final limb, components, and refinements required by the FDA. - Provide clinical data to support FDA submission. - Optimize the sensor configuration and algorithm development of the hand and arm to provide meaningful sensory feedback.			
Title: Cognitive Technology Threat Warning System (CT2WS) ***Description:*** 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 cueing 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 2011 Accomplishments:*** - Integrated and packaged fully functional prototype systems, both hardware and software, for extended field testing in a range of real environments including desert and tropical conditions. - Conducted mid-phase Test Readiness Review that validated both the maintenance of the performance efficacy previously demonstrated and suitable device ruggedization to support extended field testing. - Conducted two field tests, one in open desert terrain at Yuma Proving Ground, the other in tropical terrain in Hawaii. Results showed excellent performance, with an 89% probability of detection and a 0.002% probability of false alarm. The system outperformed trained human observers using binoculars, who achieved a 60% probability of detection. - Improved operator interface design to allow operator to monitor and enhance real-time detection and classification performance. - Coordinated with ARMY Night Vision Lab for test and evaluation in Phase 3, and possible transition beyond Phase 3. ***FY 2012 Plans:***	8.533	1.750	-

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Extend algorithms to handle imagery from Army and Marine Corps systems such as the Cerebus SCOUT, which generate visible, IR, and radar imagery from mast-mounted systems. - Improve algorithms to increase frame rate. - Improve brain machine interface to use wearable dry electroencephalogram (EEG) sensors. - Integrate and package threat warning system prototype. - Perform extended field testing and evaluation at sites selected by Night Vision Lab.			
Title: Neovision2 ***Description:*** Biological vision systems have the exquisite ability to recognize, categorize, and learn new objects in fractions of a second. While animals and humans accomplish this seemingly effortlessly and constantly, computational vision systems have, to date, been unable to replicate this feat of biology. The Neovision2 program is pursuing an integrated approach to developing an advanced object recognition capability based on the visual pathways in the mammalian brain. Specifically, this program will develop a cognitive sensor technology with limited size, weight, and power that transforms data from an imaging sensor suite into communicable knowledge for mobile, autonomous surveillance systems. To achieve the vision, the program will utilize advanced device design, signal processing and mathematical techniques across multiple brain regions to revolutionize the field and create an electronic neuro-biological (neuromorphic) vision system. ***FY 2011 Accomplishments:*** - Completed algorithm design and partial implementation of next-generation neuromorphic vision system capable of emulating the entire mammalian visual pathway, from the retina to object recognition. - Completed hardware design and partial fabrication of breadboard neuromorphic object recognition systems with the goal of enhanced visual function capabilities beyond state of the art, that met size, weight, and power constraints for unmanned systems. - Began spike-sorting and modeling selected physiological data sets to support object-recognition algorithm development. - Coordinated with Joint Unmanned Air Systems Center of Excellence to identify promising technology transition opportunities, such as processing and exploitation of data onboard UAVs. ***FY 2012 Plans:*** - Complete Phase 1 algorithm development, hardware system implementation, and physiology data collection. - Conduct Phase 1 test and evaluation. For algorithms, compare performance (probability of detection, probability of false alarm) of neuromorphic systems to conventional, engineered systems on 150 videos taken from a tower, a low-flying helicopter, and a low-flying fixed wing aircraft. For hardware, assess degree of fidelity to the mammalian visual system, performance in collecting and processing data, and potential for low-power operation.	4.642	1.461	-
Title: Tactical Biomedical Technologies	10.978	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**PROJECT** MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: 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 sites of bleeding in the thorax or abdomen. This effort continues in FY 2012 in PE 0602115E, Project BT-01. ***FY 2011 Accomplishments:*** - Identified targeting ligand/receptor pairs that show specific and selective binding only to wounded tissue. - Developed a polymeric carrier material that demonstrates conformal coverage in a severe splenic injury model. - Initiated an integrated targeting ligand/polymeric carrier material that can be delivered to a closed, intracavity space and binds specifically to damaged tissue as demonstrated in situ by immunohistology. - Demonstrated induction of a patterned regenerative response in a small animal limb when treatment with bone morphogenetic protein-2 is concurrent with natural wound closure. - Began planning for capability to manufacture a set of commonly-used organic pharmaceuticals in a small form-factor device while maintaining comparable mass efficiency to shelf-stable products. - Developed initial plans to build a continuous flow chemistry device platform for manufacturing multiple pharmaceuticals of DoD relevance.			
Title: Military Medical Imaging ***Description:*** The Military Medical Imaging thrust will develop medical imaging capabilities to support military missions and operations. Examples include novel technologies to miniaturize and enhance the capabilities and speed of computerized axial tomography (CAT) scanners and to develop non-invasive imaging modalities for use by medics. The emergence of advanced medical imaging includes newly recognized physical properties of biological tissue, or metabolic pathway, or physiological function in order to map it into an image of diagnostic utility and performance. This effort continues in FY 2012 in PE 0602115E, Project BT-01. ***FY 2011 Accomplishments:*** - Identified data types required to recreate traumatic battlefield events. - Recreated battlefield engagements using open-source data to facilitate visual presentation using Real World software. - Demonstrated and independently verified that visible light with orbital angular momentum (OAM) induces 1.5% nuclear polarization equivalent to a 2000T magnet.	3.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Endowed a 12.8 kiloelectron volt (keV) X-ray beam with OAM equal to 40, which is the highest OAM value imparted for that X-ray energy. - Demonstrated X-rays with OAM induces 0.15% nuclear polarization, which is 200x larger than current state of the art.			
Title: Reliable Neural-Interface Technology (RE-NET) ***Description:*** Wounded warriors with amputated limbs cannot fully exploit recent advances in prosthetic-limb technology because the neural interfaces used to extract limb-control information are low-performance and unreliable. The goal of the Reliable Neural-Interface Technology (RE-NET) program is to develop the technology and systems needed to reliably extract information from the nervous system at the scale and rate necessary to control state-of-the-art high-performance prosthetic limbs. In support of this goal, the RE-NET program is developing methods to quantitatively assess, model, predict, and accelerate the leading causes of neural interface degradation and failure. The program will also increase the channel-count (amount information) of reliable peripheral-nervous-system interfaces and increase the operational lifetime (reliability) of central-nervous-system interfaces. Through this focus on reliability and high-level performance, the RE-NET program will enable clinically relevant technology transitions in support of wounded warriors. This effort continues in FY 2012 in PE 0602115E, Project BT-01. ***FY 2011 Accomplishments:*** - Identified manufacturing defects in commercially produced state-of-the-art cortical probes. - Developed prototype meandering-microwire electrodes that have a mechanical stiffness that is 1000 to 1,000,000 times more compliant than existing state-of-the-art neural microprobes in each axis. - Demonstrated unique experimental capability to perform chronic in vivo high-resolution 2-photon microscopy of large cortical regions. - Demonstrated open-source software that can rapidly and accurately process high-resolution 3-D neuroimaging data to clearly map neural tissue (e.g., vasculature, shape and location of neurons, microglia, astrocytes, etc.). - Incorporated advanced adaptive-learning algorithms into open-source cell-characterization software to automate cell identification and sorting. - Expanded relationship with the FDA beyond performing independent verification and testing of neural-interface advances that could speed the clinical transition of RE-NET technologies.	19.980	-	-
Title: Pathogen Defeat ***Description:*** Pathogens are well known for the high rate of mutation that enables them to escape drug therapies and primary or secondary immune responses. The Pathogen Defeat thrust area will provide revolutionary capabilities to predict future threats and to deflect pathogen evolution to non-human spaces such as animals, insects, and bacteria. This area will also determine malicious intent by monitoring key technology acquisitions and commercialization of potential dual-use technologies. Pathogen Defeat focuses not on the threats that are already known but rather on the threats of newly emerging agents and mutations in	12.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
the future, allowing pre-emptive preparation of vaccine and therapy countermeasures. This will include novel vaccine delivery systems. This program continues in FY 2012 in PE 0602115E, Project BT-01. ***FY 2011 Accomplishments:*** - Strategized methods to induce and monitor evolutionary change through the application of individual selective pressures such as variable growth conditions, host switching, and resistance to host cell antiviral strategies such as interferons. - Demonstrated a vaccine's effect at directing the outcome of viral evolution. - Developed in vivo and in vitro evolution platforms for generating datasets used to build and validate algorithms predictive of viral evolution. - Initiated concept test for predictive algorithm, biological validation system, and metrics demonstrating successful prediction of evolution. - Developed and began testing new carrier molecule for messenger RNA delivery. - Began in vitro testing of mRNA vaccine constructs.			
Title: Preventing Violent Explosive Neurologic Trauma (PREVENT) ***Description:*** The Preventing Violent Explosive Neurologic Trauma (PREVENT) program seeks to understand the causes of blast-induced traumatic brain injury (TBI), 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 in-theater conditions to assess potential TBI 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. This program continues in FY 2012 in PE 0602115E, Project BT-01. ***FY 2011 Accomplishments:*** - Investigated the long-term effects of multiple exposures to blast on warfighters following return from deployment through comparison to pre-deployment baselining across a battery of psychological, neurological, and behavioral tests and correlation to data collected from in-theater blast events. - Investigated candidate therapeutics to alleviate acute inflammation and limit chronic apoptotic injury in preclinical models.	4.324	-	-
Accomplishments/Planned Programs Subtotals	112.455	49.645	37.623

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602715E: *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**PROJECT** MBT-03: *TACTICAL AND STRATEGIC ENERGY TECHNOLOGY*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
MBT-03: *TACTICAL AND STRATEGIC ENERGY TECHNOLOGY*	-	62.579	-	-	-	-	-	-	-	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project is focused on the unique challenges facing the DoD in developing and demonstrating advanced power generation and energy storage technologies. It will address critical military needs for improved energy efficiency and availability to support a range of military missions. At the individual warfighter and small unit operations level, efforts are addressing the need for mission extending power generation and energy storage technologies with particular emphasis on portability and robustness challenges that are unique to the DoD. As electronic systems are common to all scales of power generation and energy storage and management, this project also investigates improved board-level power conversion and regulation strategies to more efficiently convert and distribute high voltages to locally required low voltages for powering integrated circuits and sensors. The project also includes an effort that is exploring ultra-high-efficiency gas turbine engines for power generation on large platforms including Navy cruisers and destroyers.

B. Accomplishments/Planned Programs ($ in Millions)

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Tactical Advanced Power (TAP)* ***Description:*** *Previously funded under Power Components in project MBT-01 The Tactical Advanced Power (TAP) program is solving high-risk, mission-critical portable power and energy challenges (approximately 1 kilowatt and below) that are unique to DoD. TAP provides near-term solutions to DoD energy needs through an integrated approach that leverages available technologies, further develops existing science, and establishes new methods of energy generation, extraction, transmission, conversion, and storage. TAP is deploying fuel cell-enabled small (hand-held) unmanned aerial vehicles for long-endurance missions (greater than 5 hours). ***FY 2012 Plans:*** - Transition deployable long-endurance small, unmanned aerial system to user community.	-	8.800	-
Title: Vulcan* ***Description:*** *Previously funded in PE 0603286E, Project AIR-01, Advanced Aerospace Systems The goal of the Vulcan program is to design, build, and ground test a pressure gain combustion (PGC) technology system that demonstrates a 20% reduction in specific fuel consumption for power generation turbine engines. PGC technology has been under development for more than a decade and considerable progress has been made in key enabling technology areas. The technology is believed mature enough to permit a dramatic new system capability. PGC, when combined with turbine engines,	-	37.779	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
offers the ability to design a new class of hybrid turbine power generation engines and Mach 4+ air breathing propulsion systems. The Vulcan system consists of a full scale PGC, a compressor, and a turbine, and has direct application to ship power generation and propulsion turbine engines, aviation turbine engines, high-mach air breathing engines, as well as commercial turbine engines of the same variety. ***FY 2012 Plans:*** - Complete risk reduction testing and demonstrations of key PGC component technologies and subsystems. - Complete fabrication of final phase II rig demonstration hardware and test. - Demonstrate pressure gain combustion in combustor components. - Demonstrate combustor/turbine interaction to verify utility of harnessing pressure gain combustion. - Develop preliminary design of a full scale gas turbine engine with an integrated PGC module.			
Title: Microscale Power Conversion ***Description:*** The Microscale Power Conversion (MPC) 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 inversely as the fourth power of the internal operating frequency. This program was previously funded in PE 0602716E, Project ELT-01. ***FY 2012 Plans:*** - Continue development of very high frequency, low-loss power switch technology for implementing large envelope-bandwidth modulators for RF power amplifiers. - Continue co-design of advanced X-band power amplifier technologies to include drain and gate bias modulation, dynamic output impedance matching, and closed-loop control to enable fast-switching power modulation. - Continue design and prototype amplifier architectures for highly efficient handling of large peak-to-average ratio RF waveforms for military systems. - Prototype demonstrations of converter efficiency and losses, including co-designed power amplifiers of many classes and approaches.	-	16.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Design low-loss packaging strategies and monolithic integration approaches for most promising amplifier-modulator circuit combinations.			
Accomplishments/Planned Programs Subtotals	-	62.579	-

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602716E: *ELECTRONICS TECHNOLOGY*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	256.631	215.178	222.416	-	222.416	222.218	246.630	277.900	257.534	Continuing	Continuing
ELT-01: *ELECTRONICS TECHNOLOGY*	256.631	215.178	222.416	-	222.416	222.218	246.630	277.900	257.534	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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B. Program Change Summary ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	286.936	215.178	204.416	-	204.416
Current President's Budget	256.631	215.178	222.416	-	222.416
Total Adjustments	-30.305	-	18.000	-	18.000
• Congressional General Reductions	-1.357	-			
• Congressional Directed Reductions	-20.000	-			
• Congressional Rescissions	-1.715	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.363	-			
• SBIR/STTR Transfer	-6.870	-			
• TotalOtherAdjustments	-	-	18.000	-	18.000

Change Summary Explanation

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

FY 2013: Increase reflects minor repricing.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Quantum Information Science (QIS)	7.141	4.700	2.350
Description: 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 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 2011 Accomplishments:*** - Demonstrated significant progress towards two-qubit gate operations.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Validated fully self-consistent full configuration interaction (FCI) simulation code. - Demonstrated novel capacitance-based charge sensing and dispersive readouts. - Conducted theoretical analysis of improvement in decoherence time resulting from dynamical decoupling schemes. ***FY 2012 Plans:*** - Explore novel materials, noise characteristics and decoherence mitigation strategies for qubits. - Develop novel intermediate-distance communication of quantum information. - Perform detailed theoretical modeling of single and double qubits. ***FY 2013 Plans:*** - Perform advanced state tomography on qubits. - Demonstrate interconversion of quantum information between different qubits technologies. - Demonstrate transport of quantum information over microscopic scales.			
Title: Terahertz Electronics ***Description:*** 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 for electronics operating in the THz regime and multiple new applications in imaging, radar, communications, and spectroscopy. 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 Modules that includes the development and demonstration of device and processing technologies for high power amplification of THz signals in compact modules. ***FY 2011 Accomplishments:*** - Demonstrated high performance fully integrated transmit and receive circuits at 0.67 THz. - Demonstrated solid state exciters and Terahertz High Power Amplifier modules at 0.67 THz. - Demonstrated key integration and metrology technologies required for microsystems utilizing 0.67 THz active device and integrated circuits. ***FY 2012 Plans:*** - Continue the development of device and integration technologies to realize compact, high performance electronic circuits operating beyond 0.85 THz.	19.085	16.413	17.250

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop key device, integration, and metrology technologies to enable the manufacture of microsystems, such as heterodyne detectors, between 0.67 and 1.03 THz for advanced communications and radar applications at sub-millimeter wave frequencies. ***FY 2013 Plans:*** - Achieve key device and integration technologies to realize compact, high performance electronic circuits operating beyond 1.03 THz.			
Title: High Frequency Integrated Vacuum Electronic (HiFIVE) ***Description:*** The objective of the High Frequency Integrated Vacuum Electronics (HiFIVE) program is to develop and demonstrate new high-performance and low-cost technologies for implementing high-power millimeter-wave sources and components. This program is developing new semiconductor and micro-fabrication technologies to produce vacuum electronic high-power amplifiers 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 2011 Accomplishments:*** - Completed advanced cathode development activities. - Initiated fabrication and initial testing of a high-power amplifier prototype device incorporating HiFIVE micro-fabrication technologies into a compact module form factor. - Demonstrated 220 Gigahertz (GHz) solid state driver amplifier technology for implementations as exciter circuits for high power amplifiers. ***FY 2012 Plans:*** - Continue fabrication and initial testing of a high-power amplifier prototype device incorporating HiFIVE micro-fabrication technologies into a compact module form factor. - Continue efforts to perform laboratory measurements of performance and validate RF power levels. - Initiate integration of compact amplifier technology at G-band in a miniaturized tube form factor. ***FY 2013 Plans:*** - Demonstrate integrated and compact amplifier technology at G-band in a tube form factor. - Complete laboratory measurements of performance of miniaturized tube amplifier at 220GHz.	7.511	5.000	5.000
Title: Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) ***Description:*** The vision of the Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) program is the development of biological-scale neuromorphic electronic systems for autonomous, unmanned, robotic systems where humans are	23.706	29.555	24.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

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

currently the only viable option. The successful development of this technology will revolutionize warfare by providing intelligent terrestrial, underwater, and airborne systems that remove humans from dangerous environments and remove the limitations associated with today's remote-controlled robotic systems. Applications for neuromorphic electronics include not only robotic systems, but also natural human-machine interfaces and diverse sensory and information integration applications in the defense and civilian sectors. If successful, the program will also reinvigorate the maturing microelectronics industry by enabling a plethora of computer and consumer electronics applications.

FY 2011 Accomplishments:
- Demonstrated all core microcircuit functions in hybrid complementary metal-oxide semiconductor (CMOS) electronic synapse hardware.
- Demonstrated a dynamic neural system simulation of approximately 1 million neurons that shows plasticity, self-organization, and network stability in response to sensory stimulus and system level reinforcement.
- Developed tools to design electronic neuromorphic systems of 100 billion neurons with mammalian connectivity.
- Demonstrated virtual environments with a selectable range of complexity to train and test systems.
- Specified large-scale system architecture and a chip fabrication process supporting 1 million neurons per square centimeter and 10 billion synapses per square centimeter.

FY 2012 Plans:
- Design and simulate in software a complete neural system of ~10 billion synapses and ~1 million neurons performing cognitive tasks in a virtual environment comparable to those routinely tested in mice.
- Design and validate a hardware neural system of ~10 billion synapses and ~1 million neurons.
- Demonstrate a chip fabrication process and development plan supporting ~10 billion synapses per square centimeter and ~1 million neurons per square centimeter.
- Downselect among fabrication processes for CMOS and novel synaptic memory to optimize for density and power performance.
- Refine design tools and techniques by codifying design rules and component properties and matching them to fabrication and simulation capabilities.
- Demonstrate a virtual environment supporting visual perception, decision and planning, and navigation environments fully integrated with software or hardware neural systems enabling the testing, training, and evaluation of these neural systems.
- Introduce modalities of competition within the virtual environment to further tailor the evolution of the neural systems.

FY 2013 Plans:
- Demonstrate fabricated neuromorphic chips of 1 million neurons performing behavioral tests in the virtual environment.
- Fabricate additional neuromorphic chips of 1 million neurons with more advanced communication, processing, and learning capacity.
- Design an initial multi-chip neuromorphic system of approximately 100 million neurons.

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Perform animal experiments to quantify neuronal activity in sensory, navigation, and motor brain regions. - Expand the feature set of the virtual environment to include auditory perception and proprioception. - Utilize DoD-relevant platforms such as small UAVs to demonstrate capabilities of developed systems in real environments. - Demonstrate scalability of hardware systems and future densities and power consumption for next-generation systems.			
Title: Short-range Wide-field-of-regard Extremely-agile Electronically-steered Photonic Emitter and Receiver (SWEEPER) ***Description:*** 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 2011 Accomplishments:*** - Demonstrated phase locking of multiple individual emitters (vertical cavity surface emitting lasers) to single master source on a single integrated chip - Demonstrated chip scale beam-forming and steering capability in laboratory with a 20°x14° scan window using 16 elements. ***FY 2012 Plans:*** - Demonstrate 8x8 integrated photonic chip scale array beam forming with path towards a 32x32 array. - Demonstrate 10°x10° beam steering with <20dB sidelobes.	7.334	7.466	-
Title: Electric Field Detector (E-FED) ***Description:*** 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 potentially 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.	2.795	2.304	-

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2011 Accomplishments: - Demonstrated electric field sensors sensitive to an alternating electric field of 1 millivolt (mV)/meter root hertz from 1-10,000 hertz (Hz). - Developed techniques to increase the frequency range, dynamic range and sensitivity of the electric field sensors while reducing their size. ***FY 2012 Plans:*** - Demonstrate a sensor array with at least 25 elements with high sensitivity to an alternating electric field for source localization. - Demonstrate sensors sensitive to an alternating electric field of 1 microvolt (μV)/meter root hertz from 0.5-1,000,000 hertz (Hz), sufficient for brain activity monitoring.			
Title: Self-HEALing mixed-signal Integrated Circuits (HEALICs) ***Description:*** 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. 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. As semiconductor process technologies are being scaled to even smaller transistor dimensions, there is a dramatic increase in intra-wafer and inter-die process variations, which have a direct impact on realized circuit performance, as well as significantly increased sensitivity to temperature and ageing effects. This applied research program aims to develop techniques to regain lost performance and stabilize operation of mixed-signal SoCs over system lifetimes. Consequently, the long-term reliability of DoD electronic systems is expected to be significantly enhanced. ***FY 2011 Accomplishments:*** - Continued development of self-healing mixed-signal cores. - Demonstrated significant increase in performance yield of mixed-signal cores, including a 1.8 GHz input Sigma Delta analog to digital converter (ADC) for element-level digital phased-array radar, a 60 GHz communications transceiver, and a 1 giga-samples per second time-interleaved ADC for an electronic warfare receiver, to greater than seventy-five percent with minimal power and die area overhead. - Development of a self-healing IP core library for DoD user access. ***FY 2012 Plans:*** - Integrate previously demonstrated mixed-signal cores into a full self-healing microsystems/SoCs.	10.740	15.330	6.190

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop global self-healing control at the microsystem/SoC level. - Demonstrate simulated increase in performance yield of mixed-signal SoCs to greater than ninety-five percent with minimal power and die area overhead. - Continue development of self-healing IP core library for DoD user access and demonstrate self-healing integrated circuit designs leveraging cores from multiple performer teams. ***FY 2013 Plans:*** - Demonstrate increase in performance yield of fabricated mixed-signal SoCs to greater than ninety-five percent with minimal power and die area overhead. - Make self-healing IP core library widely available for DoD user access.			
Title: Efficient Linearized All-Silicon Transmitter ICs (ELASTx) ***Description:*** The goal of the Efficient Linearized All-Silicon Transmitter ICs (ELASTx) program is the development of revolutionary high-power/high-efficiency/high-linearity single-chip millimeter (mm)-wave transmitter integrated circuits (ICs) in leading edge silicon technologies for future miniaturized communications and sensor systems on mobile platforms. 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 small munitions. The technology developed under this program could also be leveraged to improve the performance of high-power amplifiers based-on other nonsilicon technologies through heterogeneous integration strategies. Significant technical obstacles to be overcome include the development of highly efficient circuits for increasing achievable output power of silicon devices (e.g., device stacking, power combining) at mm-waves; scaling high-efficiency amplifier classes to the mm-wave regime; integrated linearization architectures for complex modulated waveforms; and robust RF/mixed-signal isolation strategies. ***FY 2011 Accomplishments:*** - Continued development of watt-level, high power added efficiency (PAE) silicon-based power amplifier (PA) circuits at Q-band frequencies. - Continued development of linearized transmitter circuits based on high PAE PAs at Q-band frequencies. - Initiated development of watt-level, high PAE silicon-based PA circuits at W-band frequencies. - Initiated development of linearized transmitter circuits based on high PAE PAs at W-band frequencies. - Continued development of on-wafer calibration techniques for deeply scaled silicon transistors, and measurement techniques for mm-wave linearized transmitter circuits with complex modulated waveforms. ***FY 2012 Plans:*** - Demonstrate watt-level, high PAE silicon-based PA circuits at Q-band frequencies.	5.491	4.806	4.272

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrate linearized transmitter circuits based on high PAE PAs at Q-band frequencies with complex modulated waveforms. - Continue development of watt-level, high PAE silicon-based PA circuits at W-band frequencies. - Continue development of linearized transmitter circuits based on high PAE PAs at W-band frequencies. ***FY 2013 Plans:*** - Demonstrate watt-level, high PAE silicon-based PA circuits at W-band frequencies. - Demonstrate linearized transmitter circuits based on high PAE PAs at W-band frequencies with complex modulated waveforms. - Initiate development of watt-level, high PAE silicon-based PA circuits at D-band frequencies. - Initiate development of linearized transmitter circuits based on high PAE PAs at D-band frequencies.			
Title: Compact Mid-Ultraviolet Technology ***Description:*** The goal of the Compact Mid-Ultraviolet Technology program is to develop compact high-brightness Middle Ultraviolet source and detector technologies based on wide band gap diode structures. This program will address a critical technology shortfall preventing mid-UV capability in portable chem-bio defense systems for aerosol detection (enhanced capability for small particulates), chem-bio identification (Raman scattering and spectroscopy), and chemical decontamination/water purification applications. The technologies will also address solar-blind detectors for missile plume identification. ***FY 2011 Accomplishments:*** - Continued development for large non-absorbing (UV transparent) low-defect-density substrate materials on which to grow devices. - Continued high-quality, highly-strained epitaxy developments to confine carriers and provide the required energy band offsets. - Increased electric injection of carriers to improve quantum efficiency of light-emitting diodes. - Continued the development of low-resistance non-absorbing contacts. - Demonstrated first optically pumped semiconductor mid-UV laser below 250 nm wavelength. ***FY 2012 Plans:*** - Demonstrate diode operation at proposed mid-UV wavelength over a broader range of operating conditions. - Increase the diameter of high-quality aluminum nitride substrates and ternary templates to enable development of optimized devices. - Demonstrate high wall plug efficiency, high brightness Light-emitting Diode (LED) operating between 250-270nm. - Demonstrate 5mW semiconductor lasers operating below 250nm in wavelength. - Design system insertions utilizing highly-efficient UV LEDs for advanced detection capability.	16.013	14.189	-
Title: Adaptive Radio Frequency Technology (ART)	14.068	21.918	25.082

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

Description: There is a critical ongoing military need for flexible, affordable, hand-held cognitive military communications systems. The Adaptive Radio Frequency Technology (ART) program will provide the warfighter with a new, fully adaptive radio platform capable of sensing the electromagnetic and waveform environment in which it operates, making decisions on how to best communicate in that environment, and rapidly adapting its hardware to meet ever-changing requirements, while simultaneously significantly reducing the size, weight and power (SWaP) of such radio nodes. ART will also equip each warfighter, as well as small-scale unmanned platforms, with compact and efficient signal identification capabilities for next-generation cognitive communications, sensing and electronic warfare applications. ART technology will also enable rapid radio platform deployment for new waveforms and changing operational requirements. ART aggregates the Feedback Linearized Microwave Amplifiers program, the Analog Spectral Processing program, and Chip Scale Spectrum Analyzers (CSSA) program, and initiates new thrusts in Cognitive Low-energy Signal Analysis and Sensing Integrated Circuits (CLASIC), RF Field-Programmable Arrays (RF-FPGA), and Dynamic Live Active Nulling (DyLAN).

FY 2011 Accomplishments:
- Continued development of feedback-linearized InP Heterojunction Bipolar Transistor (HBT) monolithic low-noise amplifiers with improved third-order-intercept point and noise figure for potential transition to signal intelligence and electronic warfare platform applications.
- Continued development of feedback linearized amplifier approaches to analog/RF applications such as high-speed/high dynamic range sample-and-holds and active impedance matching of electrically small antennas, and development of an integrated field-effect-transistor switch process in support of these applications.
- Demonstrated miniaturized, low-loss, tunable and reconfigurable RF, intermediate frequency, and sensor filter banks and continued to explore potential transition opportunities to various military communications and sensing systems.
- Continued development of ultra-high (1e5 at 3 GHz) quality-factor micro-electromechanical resonators for potential use in an RF channelizer for fast spectrum sensing in cognitive radios.
- Initiated development of novel signal recognition sensor integrated circuits that can achieve >400 times reduction in signal recognition energy as compared to state of the art sensor systems.

FY 2012 Plans:
- Complete development of feedback-linearized InP HBT monolithic low-noise amplifiers with improved third-order-intercept point and noise figure for potential transition to signal intelligence and electronic warfare platform applications.
- Complete development of feedback linearized amplifier approaches to analog/RF applications such as high-speed/high dynamic range sample-and-holds and active impedance matching of electrically small antennas, and development of an integrated field-effect-transistor switch process in support of these applications.
- Continue development of novel signal recognition sensor integrated circuits that can achieve >400 times reduction in signal recognition energy as compared to state of the art sensor systems.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiate development of reconfigurable RF circuit (RF FPGA) technologies. - Initiate development of RF signal cancellation concepts which will actively eliminate unwanted signals within a receiver. ***FY 2013 Plans:*** - Continue development of novel signal recognition sensor integrated circuits. - Continue development of reconfigurable RF circuit (RF FPGA) technologies. - Continue development of integrated cancellation circuits for the purpose of RF filter replacement in low-SWaP military radios and signal intelligence platforms.			
Title: Nitride Electronic NeXt-Generation Technology (NEXT) ***Description:*** The objective of the Nitride Electronic NeXt-Generation Technology (NEXT) program is to develop a revolutionary nitride transistor technology that simultaneously provides extremely high-speed and high-voltage swing [Johnson Figure of Merit (JFoM) larger than 5 THz-V] in a process consistent with large scale integration in enhancement/depletion (E/D) mode logic circuits of 1000 or more transistors. In addition, this fabrication process will be manufacturable, high-yield, high-uniformity, and highly reliable. The accomplishment of this goal will be validated through the demonstration of specific Program Process Control Monitor (PCM) Test Circuits such as 5, 51, and 501-stage of ring oscillators in each program phase. ***FY 2011 Accomplishments:*** - Developed high-performance Gallium Nitride Field Effect Transistors (FETs) with cutoff frequencies above 350GHz. - Achieved yield required for modest integration levels of E/D mode mixed signal circuits. - Demonstrated self-aligned structure with short gate length, novel barrier layers and reduced parasitic effects. - Developed an optimized enhancement mode power switch process to complement high frequency FET process. ***FY 2012 Plans:*** - Continue scaling efforts for self-aligned structures with short gate length, novel barrier layers and reduced parasitic elements to achieve additional cutoff frequency performance gains. - Continue transistor performance trade-space analysis to achieve ultra-fast power switching capability. - Continue development of an optimized enhancement mode power switch process to complement high frequency FET process. - Establish an integrated process for power switching and Microwave Monolithic Integrated Circuit (MMIC) capability using advanced wide band gap devices. - Increase passive element performance of MMIC process utilizing both enhancement and depletion mode devices. - Initiate development of complex analog and digital monolithically integrated circuits based on next generation gallium nitride transistors and integration processes. ***FY 2013 Plans:***	12.217	13.130	11.560

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Continue development of complex analog and digital monolithically integrated circuits based on next generation gallium nitride transistors and integration processes. - Demonstrate monolithic integration of mixed signal and power amplifier circuits.			
Title: Non-Volatile Logic ***Description:*** The objective of the Non-Volatile Logic program was to develop the theory, design, and fabrication methodology, and demonstrate example circuits that utilize new computational state variables. The program fabricated and demonstrated circuits that dissipate lower power, per logic operation, while having equal or better computational throughput as equivalent charge-based circuits. Non-Volatile Logic is an outgrowth of the Spin Torque Transfer Random Access Memory program. ***FY 2011 Accomplishments:*** - Developed circuits capable of performing logic functions based on the nano-magnetic re-orientation information and not on the movement of electrical charge. - Demonstrated fabrication techniques to make nano-magnetic based logic devices.	5.911	-	-
Title: Photonically Optimized Embedded Microprocessor (POEM) ***Description:*** Current trends in scaling microprocessor performance are projected to saturate and fall far short of future military needs. Microprocessor performance is saturating and leading to reduced computational efficiency because of the limitations of electrical communications. The Photonically Optimized Embedded Microprocessor (POEM) program will demonstrate chip-scale, silicon-photonic technologies that can be integrated within embedded microprocessors for seamless, energy-efficient, high-capacity communications within and between the microprocessor and dynamic random access memory (DRAM). This technology will propel microprocessors onto a higher performance trajectory by overcoming the "memory wall", and thus satisfy projected microprocessor performance needs for memory intensive applications. ***FY 2011 Accomplishments:*** - Demonstrated an optical transceiver (transmitter and receiver), comprised of complementary metal-oxide semiconductor (CMOS)-compatible Si photonic devices and electronic drivers, and operating at 10 gigabits/second, with a world record efficiency of 530 femtojoules per bit of data. The transmitter and receiver each performed with record energy efficiencies of 135 and 395 femtojoules per bit of data, respectively. - Demonstrated a CMOS-compatible, waveguide coupled, high-gain-bandwidth avalanche photodiode operating at 40 gigabits/second with a gain-bandwidth product of 320 gigahertz. ***FY 2012 Plans:*** - Demonstrate an eight wavelength, wavelength-division-multiplexed, CMOS-compatible, optical link with 80 gigabit/second capacity and a link energy efficiency of 970 femtojoules per bit of data.	21.159	26.000	22.417

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Develop DRAM-compatible modulator, multiplexer, coupler, and photodetector devices and associated drivers for low-power, high capacity photonic links. ***FY 2013 Plans:*** - Demonstrate a DRAM-compatible photonic link which enables photonic communication between CMOS and DRAM chips with 80 gigabits/second capacity and a link energy efficiency of 450 femtojoules per bit of data. - Continue to develop and improve CMOS-compatible modulator, multiplexer, coupler, and photodetector devices and associated drivers for low-power, high capacity photonic links for insertion in final demonstration.			
Title: Analog-to-Information (A-to-I) Look-Through* ***Description:*** *Formerly Analog-to-Information (A-to-I) Receiver Development The Analog-to-Information (A-to-I) Look-Through program will fundamentally improve the operational bandwidth, linearity, and efficiency of electronic systems where the objective is to receive and transmit information using electromagnetic (radio) waves under extreme size/weight/power and environmental conditions required for DoD applications. The A-to-I Look-Through program will develop ultra-wideband digital radio frequency (RF) receivers based on Analog-to-Information Converter (AIC) technology. Compared to conventional RF receivers, AIC-based designs will increase receiver dynamic range and frequency band of regard while reducing data glut, power consumption and size. Likewise, limitations of current art power amplifier technology in simultaneously achieving high operational bandwidth, linearity, efficiency and power has resulted in well documented instances of electronic fratricide. This program will overcome these limitations by converting digital signals directly to high power RF analog signals, thus eliminating the traditional high power amplifiers that are limited by the above-mentioned tradeoffs. Transition is anticipated into airborne SIGINT and electronic warfare systems, as well as ground-based special operations forces systems. ***FY 2011 Accomplishments:*** - Completed integration of dual-channel Nyquist Folding A-to-I Receiver prototypes. - Developed and implemented novel algorithms for processing of realistic, Nyquist-folded signal data. - Conducted multiple ground and flight tests of the Nyquist Folding Receiver, detecting and measuring a wide range of signal types in operationally-realistic environments. - Initiated the transmit thrust efforts. ***FY 2012 Plans:*** - Finalize implementation and testing of A-to-I receiver data processing algorithms with focus on improving algorithm robustness against operationally-realistic conditions. - Finalize technology transition plans and transition A-to-I receivers to one or more operationally-focused end user organizations. - Develop and demonstrate through analysis, simulation and measurement suitable Look-Through transmitter architectures.	11.429	11.500	3.800

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Design, tape out and characterize in laboratory environment Look-Through transmitter cells and signal combining structures. - Design, tape out and characterize in laboratory environment Look-Through transmitters with high linearity, high power, wide bandwidth and high efficiency. ***FY 2013 Plans:*** - Complete design, tape out and testing of full-scale Look-Through transmitters with focus on insertion into specific DoD systems of interest. - Complete insertion of Look-Through transmitters into DoD systems of interest and demonstrate the transmitter performance in operationally-realistic environments.			
Title: Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) ***Description:*** The Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) program addresses the passive imaging needs for multi-band, wide field of view (FOV) and high-resolution imaging for ground and near ground platforms. The AWARE program aims to solve the technological barriers that will enable FOV, high resolution and multi-band camera architectures by focusing on four major tasks: high space-bandwidth product (SBP) camera architecture; small pitch pixel focal plane array architecture; broadband focal plane array architecture; and multi-band focal plane array architecture. The AWARE program demonstrates technologies such as detectors, focal plane arrays, read-out integrated circuitry, and computational imaging that enable wide FOV and high space bandwidth, novel optical designs, high resolution and multiple wavelength band imagers. These technologies will be integrated into subsystem demonstrations under the related MT-15 project in PE 0603739E. This program also includes technologies previously addressed in the Wide Field of View (formerly MultiScale Optical Sensor Array Imaging (MOSAIC)) program. ***FY 2011 Accomplishments:*** - Constructed and demonstrated a compact, multiscale, 1.5 Gigapixel snapshot imaging system with a potential capacity of 2.5 Gigapixels. The aperture of the camera is 4 inches with a Field of View (FOV) of 120 x 70 degrees and an achieved resolution of 64 microradians. The volume of the optical system is approximately 3 orders of magnitude smaller than state of the art Gigapixel capable snapshot imagers. - Designed next generation imaging systems with 10 -20 microradians resolution over large fields (120 x 70 degrees). ***FY 2012 Plans:*** - Fabricate the AWARE 10 Gigapixel system with about 20 Gigapixels, including second generation micro-optics and electronics. The key objectives will be to reduce the iFOV by 3X relative to the Phase I camera and achieve a 4X reduction in electronics SWaP. ***FY 2013 Plans:***	7.578	8.000	9.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Complete fabrication of the AWARE 50 camera (30 Gigapixels) with 2-3X improvement over AWARE 10 with < 1 cm ground sample distance (GSD) at 1 km. - Complete testing and design studies for a smaller scale microcamera for additional size, weight and power (SWaP) reduction.			
Title: Diverse & Accessible Heterogeneous Integration (DAHI) ***Description:*** Prior DARPA efforts have demonstrated the ability to monolithically integrate inherently different semiconductor types to achieve near-ideal "mix-and-match" capability for DoD circuit designers. Specifically, the Compound Semiconductor Materials On Silicon (COSMOS) program, in which transistors of Indium Phosphide (InP) can be freely mixed with silicon complementary metal-oxide semiconductor (CMOS) circuits to obtain the benefits of both technologies (very high speed and very high circuit complexity/density, respectively). The Diverse & Accessible Heterogeneous Integration (DAHI) effort will take this capability to the next level, ultimately offering the seamless co-integration of a variety of semiconductor devices (for example, Gallium Nitride, Indium Phosphide, Gallium Arsenide, Antimonide Based Compound Semiconductors), microelectromechanical (MEMS) sensors and actuators, photonic devices (e.g., lasers, photo-detectors) and thermal management structures. This capability will revolutionize our ability to build true "systems on a chip" (SoCs) and allow dramatic size, weight and volume reductions for a wide array of system applications. FY 2011 and FY 2012 incorporates the COSMOS program into DAHI. In the Applied Research part of this effort, high performance RF/optoelectronic/mixed-signal SoCs for specific DoD transition applications will be developed as a demonstration of the DAHI technology. In addition, in order to provide maximum benefit to the DoD, as these processes are developed, they will be transferred to a manufacturing flow and made available (with appropriate computer aided design support) to a wide variety of DoD laboratory, FFRDC, academic and industrial designers. Manufacturing yield and reliability of the DAHI technologies will be characterized and enhanced. This program has basic research efforts funded in PE 0601101E, Project ES-01. ***FY 2011 Accomplishments:*** - Continued to optimize compound-semiconductor on silicon process technologies for fine-scale heterogeneous integration in very large-scale integrated circuit with high manufacturing and performance yield. - Continued design and test of advanced mixed-signal circuit demonstrators, specifically heterogeneously-integrated wideband, ultra-high-linearity digital-to-analog converters with in situ silicon enabled calibration and linearization. - Initiated a multi-user compound-semiconductor on silicon foundry process which will ultimately be accessible to the wider defense and commercial integrated circuit design community. ***FY 2012 Plans:*** - Complete design and test of advanced heterogeneously-integrated wideband, ultra-high-linearity digital-to-analog converters with in situ silicon enabled calibration and linearization.	13.900	14.772	26.794

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiate design and test of higher complexity heterogeneously-integrated wideband, ultra-high-linearity analog-to-digital converters with in situ silicon enabled calibration and linearization. - Continue multi-user compound-semiconductor on silicon foundry process, which will ultimately be accessible to the wider defense and commercial integrated circuit design community. - Develop new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices, including interconnect and thermal management approaches. - Initiate design of high complexity heterogeneously integrated RF/optoelectronic/mixed signal and circuits, such as wide band RF transmitters, optoelectronic RF signal sources, and laser radar and imaging array chips. ***FY 2013 Plans:*** - Optimize new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices, including interconnect and thermal management approaches. - Initiate manufacturing, yield and reliability enhancement for an expanded multi-user foundry capability based on developed diverse heterogeneous integration processes. - Continue design of high complexity heterogeneously integrated RF/optoelectronic/mixed signal and circuits, such as wide band RF transmitters, optoelectronic RF signal sources, and laser radar and imaging array chips.			
Title: Leading Edge Access Program (LEAP) ***Description:*** The goal of the Leading Edge Access Program (LEAP) is to enable university, industry, and government lab access to on-shore state of the art Complementary Metal-Oxide Semiconductor (CMOS) technology for performing advanced integrated circuit (IC) research of benefit to the DoD. Specifically, LEAP offers foundry access at a substantially reduced cost for CMOS technology nodes of 45 nanometers (nm) and below. Currently much of the IC design work performed using advanced technology nodes, including that done for the DoD, uses off-shore facilities in Asia and Europe. This results in substantial intellectual property (IP) development outside the U.S. and creates a number of difficulties for technology transition of DoD-critical applications. This program will stimulate U.S.-based advanced design research, providing top researchers early and partially subsidized access to validate and test innovative ideas and facilitate a more natural transition of these ideas. ***FY 2011 Accomplishments:*** - Completed fabrication and testing of designs at 45 nm Silicon-on-Insulator (SOI) and 32 nm SOI. - Initiated transition discussions to 22 nm bulk CMOS and 22 nm SOI. - Demonstrated over 20 different digital and mixed-signal designs.	3.492	1.000	3.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Held a workshop with potential users highlighting technology capabilities. ***FY 2012 Plans:*** - Develop new foundry offerings in either 22 nanometers or other technologies such as silicon photonics. - Investigate access to alternate semiconductor fabrication facilities. ***FY 2013 Plans:*** - Initiate discussions and develop plans for 14 nanometer and 3D access.			
Title: Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T) ***Description:*** The Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T) program is developing technology for self-contained chip-scale inertial navigation and precision guidance. This technology promises to effectively mitigate dependence on Global Positioning System (GPS) or any other external signals, and enable uncompromised navigation and guidance capabilities. The program will enable positioning, navigation and timing functions without the need for external information updates by employing on-chip calibration, thereby overcoming vulnerabilities which arise in environments where external updates are not available such as caves, tunnels, or dense urban locations. The technologies developed will enable small, low-power, micro-gyroscopes capable of operating in both moderate and challenging dynamic environments; chip-scale primary atomic clock standards; and on-chip calibration systems for error correction. Advanced micro-fabrication techniques allow a single package containing all the necessary devices (clocks, accelerometers, gyroscopes, and calibration mechanisms) to be incorporated into a volume the size of a sugar cube. The small size, weight and power of these technologies and their integration into a single package responds to the needs of guided munitions, unmanned aerial vehicles (UAVs) and individual soldiers. The successful realization of a Micro PN&T device is dependent on developing fundamentally new batch microfabrication processes, gaining an understanding of the sources and effects of error at the micro-scale, and exploring new combinatorial physics. Innovative 3-D microfabrication techniques will allow co-fabrication of different materials and devices on a single chip. Clocks, gyroscopes, accelerometers, calibration stages, and 3D structures could be integrated into a small, low power architecture. This co-location of different inertial and timing devices opens the possibility for utilization of combinatorial physics in a single micro-system, enabling fast start-up time, increased bandwidth and long-term stability, thus effectively providing very accurate navigation devices. Advanced research for the program is budgeted in PE 0603739E, Project MT-12. ***FY 2011 Accomplishments:*** - Demonstrated 3-D fabrication technique for bubble-blow ULE(TM) glass in a toroidal-shape and silicon micromachined molding process for high Q material hemispheres.	7.963	10.595	16.701

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Explored high aspect ratio etching of fused silica for wafer-scale fabrication and packaging of sensors completely comprised of fused silica. ***FY 2012 Plans:*** - Identify fabrication method to co-fabricate clocks and inertial sensors into a single low power package for navigation microsystems. - Model internal and external sources of error for inertial devices. - Identify self-calibration techniques to compensate for long-term drift. ***FY 2013 Plans:*** - Demonstrate a fabrication technique that allows for the integration of timing and inertial measurement unit into a small package. - Demonstrate the co-fabrication of an inertial sensor and a calibration stage to enable integration of error correction technologies on the same stage. - Use models for internal and external sources of error to develop on-chip calibration algorithms. - Develop an architecture for chip-scale combinatorial atomic navigator. - Demonstrate combinatorial physics for fast startup time, high accuracy inertial devices.			
Title: Advanced X-Ray Integrated Sources (AXIS) ***Description:*** The objective of the Advanced X-Ray Integrated Sources (AXIS) program is to develop tunable mono-energetic X-ray sources that are spatially coherent with greatly reduced size, weight and power while dramatically increasing their electrical efficiency through application of micro-scale engineering technologies such as MEMS and NEMS. Such X-ray sources will enable new versatile imaging modalities based on phase contrast which are 1000X more sensitive than the conventional absorption contrast imaging. Such imaging modalities should enable reverse engineering of integrated circuits to validate trustworthiness as well as battlefield imaging of soft tissues and blood vessel injuries without the injection of a contrast enhancing agent in blunt trauma. It will also reduce radiation dose required for imaging. The Applied Research component of this effort will focus on applying basic research discoveries to the development of compact, pulsed X-ray source. Such sources are a necessary component to enable future technologies with high-speed motion imaging capabilities and the reverse engineering of integrated circuits. This program also includes related basic research efforts funded under PE 0601101E, Project ES-01. ***FY 2012 Plans:*** - Develop advanced designs for compact and energy efficient X-ray sources that are spectrally tunable with narrow energy width. - Develop a coded array of micro-focused X-ray sources for phase contrast imaging. - Design and evaluate the performance potential of a short lifetime photoconductor switched tip-on-post (Spindt) field emitter.	-	4.500	11.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop a miniaturized wafer scale electron accelerator and electron storage ring. - Demonstrate the feasibility of an advanced hard x-ray source based on a whispering gallery mode resonator with multi-layer reflectivity for confinement and high gain material. ***FY 2013 Plans:*** - Fabricate and demonstrate a short lifetime photoconductor switched tip-on-post (Spindt) field emitter with short pulse duration, high pulse repetition rate and low emittance. - Demonstrate the feasibility of an advanced hard X-ray source based on a whispering gallery mode resonator with multi-layer reflectivity for confinement and gain.			
Title: Microscale Plasma Devices (MPD) ***Description:*** The goal of the Microscale Plasma Devices (MPD) program is to design, develop, and characterize MPD technologies, circuits, and substrates. The MPD program will focus on development of fast, small, reliable, carrier dense, microplasma switches capable of operating in extreme conditions such as high-radiation and high-temperature environments. Specific focus will be given to methods that produce efficient, high-pressure (up to or even beyond atmospheric pressure) generation of ions, radio frequency energy, and light sources. Applications for such devices are far reaching, including the construction of complete high-frequency plasma-based logic circuits, and integrated circuits with superior resistance to radiation and extreme temperature environments. It is envisaged that both two and multi-terminal devices consisting of various architectures will be developed and optimized under the scope of this program. MPDs will be developed in various circuits and substrates to demonstrate the efficacy of different unique approaches. The MPD applied research program is focused on transferring the fundamental scientific advances funded by PE 0601101E, Project ES-01 to produce complex circuit designs that may be integrated with commercial electronic devices. It is expected that the MPD program will result in the design and modeling tools, as well as the fabrication capabilities necessary to commercially manufacture high-performance microscale plasma device based electronic systems for advanced DoD applications. ***FY 2012 Plans:*** - Complete definition of complex circuit demonstrations of DoD relevant high-performance microplasma electronics. - Develop microplasma simulation design tools (MSDT) for commercial integration of optimized microplasma electronics with commercial electronic devices. - Design and develop a complete set of microplasma electronics capable of producing a complete radiation hardened RF system. - Develop a microcavity material capable of passively protecting against high power microwave pulses. ***FY 2013 Plans:*** - Optimize microplasma simulation design tool (MSDT) for commercial development of microplasma based electronics.	-	4.000	9.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Begin construction of a full microplasma electronics based radiation hardened RF system. - Initial testing of a microcavity material for high power microwave protection.			
Title: IntraChip Enhanced Cooling (ICECool) ***Description:*** The IntraChip Enhanced Cooling (ICECool) program is exploring disruptive technologies that will remove thermal barriers to the operation of military electronic systems, while significantly reducing size, weight, and power consumption. These thermal barriers will be removed by integrating thermal management into the chip, substrate, or package technology. Successful completion of this program will close the gap between chip-level heat generation density and system-level heat removal density in RF arrays and embedded computers. Specific areas of focus in this program include overcoming limiting evaporative and diffusive thermal transport mechanisms at the micro/nano scale to provide an order-of-magnitude increase in on-chip heat flux and heat removal density, determining the feasibility of exploiting these mechanisms for intrachip thermal management, characterizing the performance limits and physics-of-failure of high heat density, intrachip cooling technologies, and integrating chip-level thermal management techniques into prototype high power electronics in the form factor of RF arrays and embedded computing systems. ***FY 2013 Plans:*** - Investigate advanced evaporative, thermoelectric, and diffusive technologies for intrachip thermal management in electronic and photonic components. - Determine fundamental limits of advanced thermal technologies and feasibility of implementation into compact defense electronic and photonic systems. - Investigate benefits to system-level performance and size, weight, power, and cost (SWaPC) through the use of intrachip thermal management technologies.	-	-	8.000
Title: In vivo Nanoplatforms (IVN) ***Description:*** The In vivo Nanoplatforms (IVN) program seeks to develop the nanoscale systems necessary for in vivo sensing and physiologic monitoring and delivery vehicles for targeted biological therapeutics. The nanoscale components to be developed will enable continuous in vivo monitoring of both small (e.g. glucose, lactate, and urea) and large molecules (e.g. biological threat agents). A reprogrammable therapeutic platform will enable tailored therapeutic delivery to specific areas of the body (e.g. cells, tissue, compartments) in response to traditional, emergent, and engineered threats. The key challenges to developing these systems include safety, toxicity, biocompatibility, sensitivity, response, and targeted delivery. The IVN program will have diagnostic and therapeutic goals that enable a versatile, rapidly adaptable system to provide operational support to the warfighter in any location.	-	-	5.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2013 Plans: - Begin development of initial in vivo diagnostic platform for small molecules. - Initiate development of in vivo therapeutic platform for treatment of infectious disease. - Begin technical analysis of safety and efficacy for proposed in vivo platforms.			
Title: Pixel Network (PIXNET) for Dynamic Visualization	-	-	12.000
Description: The Pixel Network (PIXNET) for Dynamic Visualization program aims to develop infrared imaging components and the necessary application programming interface (API) system to provide real-time and dynamic tactical visualization of battlefield situation awareness and exploitation at individual level and at collective ensemble. The goal is to enable one-to-many and many-to-one real-time intelligence, surveillance and reconnaissance (ISR) data and metadata to maximize mission relevancy and minimize decision time during day/night operations. The program will focus on significant reduction in cost, size, weight and power (SWaP) of infrared sensor components to enable portability and ability to deploy widely to all participants in the theatre. Development of wafer scale IR sensor and coolers for low cost manufacturing will provide a price point that will allow them to be deployed to each warfighter. The emphasis on a small form -factor (<3.5 cm3) will naturally enable new opportunities such as surveillance with micro-UAVs, networked handheld devices with fused imaging capabilities to share tactical information at troop level, and intelligence for rapid decision/action. The phenomenology of different infrared wavelengths will be exploited for targets of interest and only relevant data will be transmitted, thus reducing data burden over the network. Having the capability of PIXNET at the soldier level will increase situational awareness and will enable more effective tactics, techniques and procedures (TTP). PIXNET will take advantage of small computing platforms such as Android cell phones API to integrate and demonstrate digital image data distribution and signal processing via wireless connectivity. The Program Executive Office, Space Sciences Laboratory, PM Optics USMC and industry will be the transition partners. ***FY 2013 Plans:*** - Develop and review IR camera design and overall architecture that will demonstrate digital image data distribution and signal processing via wireless connectivity using a cell phone or PDA platform. - Develop CMOS compatible wafer scale manufacturing of integrated image sensor-cooler for very low SWaP IR camera technology. - Develop wafer scale low-cost and high transmission optics. - Develop strategy to reduce IR image sensor cost by 15 to 50X. - Demonstrate rudimentary operation of networked IR sensors for digital signal processing and image data distribution.			
Title: Microscale Power Conversion (MPC)	15.000	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Microscale Power Conversion (MPC) 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 inversely as the fourth power of the internal operating frequency. In FY 2012, MPC moves to PE 0602715E, Project MBT-03. ***FY 2011 Accomplishments:*** - Initiated design and initial fabrication of critical sub-circuits and performed measurements in laboratory in order to design and prototype amplifier architectures for highly efficient handling of large peak-to-average ratio RF waveforms for military systems. - Initiated development of theoretical design and analyses to understand the high-frequency trade-off space of relevant circuit designs and topologies. - Initiated co-design of advanced X-band power amplifier technologies to include drain and gate bias modulation, dynamic output impedance matching, and closed-loop control to enable fast switching power modulation. - Optimized transistor performance to include ultra-fast power switching capability. - Initiated development of very high frequency, low-loss power switch technology for implementing large envelope-bandwidth modulators for RF power amplifiers. - Developed new fabrication techniques for incorporating high frequency transistors and devices compatible with integrated power amplifier topologies.			
Title: Carbon Electronics for RF Applications (CERA) ***Description:*** The Carbon Electronics for RF Applications (CERA) program developed a wafer-scale graphene (2-D carbon monolayer) synthesis process resulting in films with excellent mobility, uniformity and layer control (down to single monolayer films). These carbon films will be used to develop ultra-low power, high-speed field effect transistors optimized for RF-applications (RF-FET). The program concluded with a demonstration of a low power, low noise amplifier (LNA) using graphene-field effect transistors (FETs) as the channel material. ***FY 2011 Accomplishments:*** - Optimized synthesis process for wafer-scale graphene thin films. - Optimized RF-FETs based on graphene channels. - Increased area of graphene synthesis to wafer-scale dimensions.	6.958	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated film thickness control down to single monolayers and bi-layers. - Demonstrated low power, high performance RF-FETs with graphene. - Demonstrated initial graphene channel based RF-FETs in mixer circuits.			
Title: Quantum Sensors ***Description:*** The Quantum Sensors program exploited non-classical effects to improve the resolution and range of military sensors. The objective of the program was to enhance sensitivity, resolution, and effectiveness of electromagnetic sensors beyond what is classically possible. In the initial effort, the types of sensors that propagate entangled light out to and back from a target were proven to be ineffective when realistic scattering and absorption occur between the source and the target. Sensors that propagate classical light to the target but use non-classical effects only in the receiver were shown to provide qualitative advantages over their classical counterparts. These include compensation for soft aperture losses using squeezed vacuum injection and compensation for detectors' quantum inefficiency using noiseless amplification. ***FY 2011 Accomplishments:*** - Tested and demonstrated system performance. - Made technology available to the Services for further development.	5.389	-	-
Title: Spin Torque Transfer-Random Access Memory (STT-RAM) ***Description:*** The Spin Torque Transfer-Random Access Memory (STT-RAM) program developed materials and processes to fully exploit the spin-torque transfer (STT) phenomenon for creating "universal" memory elements. This program developed the core technology for exploiting spin-torque transfer and related phenomena for producing large-scale non-volatile memories. Compatibility and stability with expected mainstream processes for semiconductor electronics and patterned media is an important attribute that should enable significant leverage for these new technologies in delivering early demonstrations and in gaining wider acceptance. ***FY 2011 Accomplishments:*** - Demonstrated improved magnetic materials and non-volatile memory bits, in the STT architecture, with 100x faster speed and 1000x lower power for switching than flash memory. - Demonstrated manufacturing processes that produce fast low power STT memory arrays in high yield.	4.565	-	-
Title: Radio Frequency Photonics Technology (RPT) ***Description:*** The Radio Frequency Photonics Technology (RPT) program developed components and microsystems to revolutionize deployed signal intelligence (SIGINT) gathering capabilities. The radio frequency (RF) spectrum contains innumerable friendly and adversarial signals of interest including: voice and data communications, electronic signatures, and navigation information. Conventional electronic systems are challenged in detecting weak signals in the presence of strong	16.929	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
ones (low-linearity) across a broad range of frequencies (narrow-band). The RPT program aimed to efficiently capture all RF signals of interest by developing broad-band (>10 gigahertz) high-linearity (>70 decibels dynamic-range) optical components and microsystems. RPT enables linear broadband microsystems such as remote links, channelizers, and analog-to-digital converters (ADCs). The RPT program will reduce susceptibility to electronic attack, increase the probability-of-intercepting (POI) adversaries on their first-pulse transmission, and increase information awareness 1000-fold. ***FY 2011 Accomplishments:*** - Developed on-chip integrated optical waveguides with loss of less than 0.1dB/m using two different approaches based on silicon dioxide-core and silicon nitride-core waveguides. This enables 100 ns of delay on a chip. - Developed an analog to digital converter performance multiplier architecture that enables a 3 bit enhancement to electronic ADCs.			
Title: Ultrabeam ***Description:*** The goal of the Ultrabeam program was to demonstrate the world's first gamma-ray laser using laboratory equipment. Compact gamma ray lasers can enable the development of new and more effective radiation therapies and radiation diagnostic tools for medical and materials/device inspection applications. This unique X-ray laser technology could also eventually enable the development of compact, laboratory-scale high-brightness coherent sources for 3-D molecular scale imaging of living cells and debris-free advanced lithography. ***FY 2011 Accomplishments:*** - Demonstrated stable consistent operation of an Xe(L,M) X-ray with indirect evidence for inferred pulse energies of 10's megajoules (mJ) and pulse durations as short as 10's of attoseconds. - Modeled gamma-ray gain of >100 per cm at ~100 kilo electron volt (keV) photon energy.	1.846	-	-
Title: Chip-to-Chip Optical Interconnects (C2OI) ***Description:*** The performance of electronic interconnect technologies, particularly for implementing high-speed communications channels on printed circuit boards and back planes, is currently being outpaced by the ever-advancing needs of complementary metal-oxide semiconductor (CMOS) microprocessor chips. This performance gap in the on-chip and between chip interconnection technology will create substantial data throughput bottlenecks, deleteriously affecting future military-critical sensor signal processing systems. To address this pressing issue, the Chip-to-Chip Optical Interconnects (C2OI) program developed optical technology for implementing chip-to-chip interconnects at the board and backplane level. ***FY 2011 Accomplishments:*** - Demonstrated a chip-scale, opt-electronic transceiver circuit based on C2OI technology operating at 1 terabit per second (consisting of twenty-four bidirectional channels each operating at 20 gigabits/second).	1.322	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	**R-1 ITEM NOMENCLATURE** PE 0602716E: *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrated the integration of C2OI opt-electronic transceiver technology with commercially fabricated circuit boards by demonstrating fully operational data channels operating at 15 gigabits/second link.			
Title: Near-Junction Transport (NJTT) ***Description:*** Miniaturization and integration in microelectronics have led to a thermal bottleneck where dense logic circuits, mixed-signal analog and digital circuits, and RF electronics are all limited by energy dissipation in the small volumes adjacent to the electronically-active junctions. The Near-Junction Thermal Transport (NJTT) program explored heat conduction and hot spot mitigation through the materials layers near a high-power device junction. This program concentrated on development of specific materials and substrate bonding techniques, as well as microfluidic cooling, to enhance dissipated heat removal in the region of the active junctions of semiconductor chips. Attention was also devoted to development and verification of metrology and quantitative models for heat generation and transport in and near device junctions. Industry leaders with the expertise in developing high-power semiconductor devices are expected to demonstrate devices with significantly enhanced heat density and consequent enhancement in performance metrics. This program was a companion program to the Thermal Management Technologies (TMT) program in PE 0603739E, Project MT-12. ***FY 2011 Accomplishments:*** - Developed techniques for utilizing high conductivity substrates and liquid cooling for use in high power GaN electronics. - Designed GaN electronics that provided improved output power through improved near junction thermal management.	7.089	-	-
Accomplishments/Planned Programs Subtotals	256.631	215.178	222.416

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	234.389	98.878	174.316	-	174.316	124.530	104.474	106.474	129.352	Continuing	Continuing
AIR-01: *ADVANCED AEROSPACE SYSTEMS*	234.389	98.878	174.316	-	174.316	124.530	104.474	106.474	129.352	Continuing	Continuing

A. Mission Description and Budget Item Justification

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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	303.078	98.878	116.716	-	116.716
Current President's Budget	234.389	98.878	174.316	-	174.316
Total Adjustments	-68.689	-	57.600	-	57.600
• Congressional General Reductions	-1.227	-			
• Congressional Directed Reductions	-61.700	-			
• Congressional Rescissions	-2.050	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	2.500	-			
• SBIR/STTR Transfer	-6.212	-			
• TotalOtherAdjustments	-	-	57.600	-	57.600

Change Summary Explanation

FY 2011: Decrease reflects reductions for the Section 8117 Economic Adjustment, reductions to ongoing programs such as Arclight, ISIS, MoTr, Vulture, rescissions and the SBIR/STTR transfer offset by internal below threshold reprogrammings.

FY 2013: Increase reflects further research for hypersonic technologies and continuation of the Long Range Anti-Ship Missile Demonstration Program (LRASM).

C. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Vulture ***Description:*** The objective of the Vulture program is to develop and demonstrate the technology to enable an airborne payload to remain persistently on-station, uninterrupted and unreplenished, for over five years performing strategic and tactical	40.000	12.000	10.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603286E: *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
communications, position/navigation/timing (PNT) and intelligence, surveillance, and reconnaissance missions over an area of interest. Vulture technology enables a re-taskable, persistent pseudo-satellite capability, in an aircraft package. The technology combines the key benefits of an aircraft (flexibility & responsiveness, sensor resolution, reduced transmit/receive power, affordability) with the benefits of space assets (on-station persistence, no logistics tail, energy independence, fleet size, absence of in-country footprint). The system has potential in numerous roles: operation as a single platform, as a formation of multiple aircraft, or as a constellation providing infrastructure augmentation or recovery. The technology challenges include structural integrity of very lightly-loaded airframe structure, efficient and reliable energy collection, storage/retrieval and management, and reliability technologies capable of allowing the aircraft to operate continuously for five years. The Vulture program will conduct subscale and full-scale technology maturation and demonstration activities to prove out critical technologies. The anticipated transition partners are the Air Force and Navy. ***FY 2011 Accomplishments:*** - Conducted system requirements review. - Initiated preliminary design of the flight demonstrator aircraft. - Demonstrated component performance and reliability including energy storage, propulsion, and flight management/control systems. - Performed cantilever wing, 2-D and 3-D wind tunnel test. - Continued subsystem and risk reduction testing. - Fabricated and structurally tested critical wing sections. - Initiated energy collection system fabrication and testing. - Initiated 1 KW energy storage system fabrication and pressure test. ***FY 2012 Plans:*** - Conduct system preliminary design review. - Conduct airframe/propulsion critical design review. - Initiate fabrication and assembly of flight demonstrator (FD). - Test permeation and pressure of center spar. - Deliver tailplane assembly. - Complete propeller qualification testing. - Conduct long endurance testing of propeller motor/controller. - Complete detailed airframe certification/stress report. - Validate flight demonstrator (FD) solar array energy collection performance. - Achieve energy storage system technology measurement of solid oxide fuel cell (SOFC) power density of 250 Watts per Kilogram (250 W/kg).			

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Verify energy storage system capabilities at degradation of 12mv/1k hours in fuel cell/electrolyzer mode). ***FY 2013 Plans:*** - Conduct system critical design review. - Accomplish energy storage system technology measurement of SOFC power density of 380 W/kg and degradation of 6mv/1000 hours. - Complete first wing section. - Complete solar array build, test and installation. - Validate FD motors/propellers, solar array, energy storage system, and ground control system delivery. - Complete airframe build. - Complete system integration and rollout of air vehicle. - Conduct FD system assembly, integration, checkout, and ground testing. - Test ground control system with hardware-in-loop. - Prepare final system safety hazard analysis report.			
Title: Persistent Close Air Support (PCAS) ***Description:*** The Persistent Close Air Support (PCAS) program will significantly increase close air support (CAS) capabilities by developing a system to allow continuous CAS availability and lethality to the supported ground commander. The enabling technologies are: manned/unmanned attack platforms, next generation graphical user interfaces (GUI), data links, digital guidance and control, and advanced munitions. PCAS will demonstrate the ability to digitally task a CAS platform from the ground to attack multiple/simultaneous targets. PCAS will allow the Joint Tactical Air Controller (JTAC) the ability to rapidly engage multiple moving targets simultaneously within the area of operation. PCAS's ability to digitally task a CAS platform to attack multiple/ simultaneous targets would improve U.S. ground forces operations and speed of attack. The system will be designed to reduce collateral damage and potential fratricide to friendly forces. The anticipated transition partner is the Air Force. ***FY 2011 Accomplishments:*** - Conducted trade studies for an integrated PCAS system. - Completed conceptual design reviews of the unmanned A-10 demonstration aircraft and JTAC kit. - Created an initial technology maturation plan and conducted program risk reduction activities to ensure a successful live-fire demonstration of the PCAS system. - Initiated subcomponent developer critical enabling technology designs that will complement the system integrator A-10 and JTAC Kit designs. ***FY 2012 Plans:*** - Conduct system requirements reviews of the unmanned A-10 demonstration aircraft and prototype JTAC kit.	18.600	18.500	20.216

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603286E: *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Conduct preliminary design reviews to encapsulate trade studies, technology maturation plan, and program risk reduction activities to begin integration of PCAS A-10 and JTAC kit components. - Complete government furnished equipment transfer of A-10 aircraft, LITENING Targeting pods, and targeting software. - Secure munitions acquisitions and test range support for demonstration planning. ***FY 2013 Plans:*** - Integrate subcomponent developer critical enabling technology components into system integrator A-10 and JTAC kit designs. - Perform initial field testing of Government furnished JTAC targeting software with Service partner. - Perform initial modifications to unmanned A-10 demonstration aircraft and conduct software and hardware ground testing. - Complete initial designs of next generation JTAC kit and perform hardware and software breadboard testing. - Continue modifications to the unmanned A-10 demonstration aircraft based on software and hardware ground testing results. - Begin initial flight tests of unmanned A-10 aircraft for preliminary safety evaluations.			
Title: Advanced Aerospace System Concepts ***Description:*** Studies conducted under this program examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact/improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future programs or refocus ongoing work. Topics of consideration include: methods of defeating enemy anti-aircraft attacks; munition technologies to increase precision, range, endurance, and lethality of weapons for a variety of mission sets; novel launch systems; air vehicle control, power, propulsion, materials, and architectures; and payload and cargo handling systems. ***FY 2011 Accomplishments:*** - Performed studies of candidate technologies and developed system concepts. ***FY 2012 Plans:*** - Conduct modeling and simulation of system architectures and scenarios. - Perform feasibility experiments of candidate technologies and system concepts. ***FY 2013 Plans:*** - Perform trade studies and modeling and simulation for novel technologies. - Conduct enabling technology and sub-system feasibility experiments.	3.000	3.000	3.000
Title: Integrated Sensor is Structure (ISIS)	21.700	5.000	5.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The joint DARPA/Air Force Integrated Sensor is Structure (ISIS) program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship that will address the nation's need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly integrated lightweight multi-purpose airship structure - completely erasing the distinction between payload and platform. The ISIS concept includes ninety-nine percent on-station 24/7/365 availability for simultaneous Airborne Moving Target Indicator (AMTI) (600 kilometers) and Ground-Based Moving Target Indicator (GMTI) (300 kilometers) operation; ten years of autonomous, unmanned flight; hundreds of wideband in-theater concealed communications links; responsive reconstitution of capabilities lost by any failed space assets; plus CONUS-based sensor analysis and operation. An MOA has been signed by DARPA and the Air Force to pursue the program objectives through to transition. The ISIS technology demonstration system transitions to the Air Force in 2014. ***FY 2011 Accomplishments:*** - Conducted critical design review of demonstration system. - Conducted simulations to validate subsystem detailed designs. - Conducted risk reduction testing and demonstrations of integrated subsystems. - Manufactured initial delivery of airship envelope. - Manufactured and chamber tested portions of dual-band RF apertures. ***FY 2012 Plans:*** - Complete radar panel manufacturing process validation. - Assemble radar panels and initiate radar/aperture rooftop testing. - Assemble and initiate power system long-term bench testing. - Assemble and test radar subsystem components. - Complete envelope material seaming and testing. - Complete environmental assessment. ***FY 2013 Plans:*** - Complete radar software operational mode development. - Complete and test radar metrology system. - Complete Ground Station development. - Complete airship subsystem testing and integration. - Assemble radar panels to pill structure and perform radar/aperture testing. - Integrate airship hull and radar aperture structures.			

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Install and pre-flight test power, propulsion, and ballast systems.			
Title: Triple Target Terminator (T3) ***Description:*** The Triple Target Terminator (T3) program will develop a high speed, long-range missile that can engage air, cruise missile, and air defense targets. T3 would be carried internally on stealth aircraft or externally on fighters, bombers, and UAVs. The enabling technologies are: propulsion, data links, and digital guidance and control. T3 would allow any aircraft to rapidly switch between air-to-air and air-to-surface capabilities. T3's speed, maneuverability, and network-centric capabilities would significantly improve U.S. aircraft survivability and increase the number and variety of targets that could be destroyed on each sortie. The program is jointly funded with, and will transition to the Air Force. ***FY 2011 Accomplishments:*** - Conducted preliminary design review of T3 concepts. - Initiated T3 critical design activities. ***FY 2012 Plans:*** - Conduct hardware-in-the-loop integrated subsystem testing. - Conduct propulsion system ground testing. - Fabricate and ground test demonstration vehicles. ***FY 2013 Plans:*** - Conduct captive carry test of flight test article. - Conduct ground launch of test article. - Conduct airborne launch of test articles against three target types.	18.891	30.820	38.500
Title: Long Range Anti-Ship Missile Demonstration (LRASM) ***Description:*** In response to emerging threats, DARPA is building on recent technology advances to develop and demonstrate standoff anti-ship strike technologies to reverse the significant and growing U.S. naval surface strike capability deficit. The Long Range Anti-Ship Missile (LRASM) program is investing in advanced component and integrated system technologies capable of providing a dramatic leap ahead in U.S. surface warfare capability focusing on organic wide area target 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 are being developed, demonstrated, and integrated into a complete weapon system. The program will result in a high fidelity demonstration to support military utility assessment. LRASM is a joint DARPA/Navy effort.	67.560	24.490	39.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2011 Accomplishments: - Initiated system detailed design activity. - Developed high fidelity simulation tools and initiated system performance studies. - Completed subsystem designs and developmental testing including wind tunnel tests and propulsion direct connect tests. - Conducted system developmental tests. - Initiated long-lead procurements for flight demonstrations. - Commenced range planning activities. ***FY 2012 Plans:*** - Develop integrated hardware-in-the-loop platforms. - Complete missile seeker captive carry testing against surrogate targets. - Complete integrated system detail designs and hold critical design reviews. - Conduct high fidelity independent government performance assessment of detailed designs against key performance criteria. - Update supporting documentation including concepts of operations, flight test and safety plans, lifecycle cost estimates, and transition plans. - Commence fabrication, assembly, integration, and checkout of flight test vehicles for initial incremental test events. - Complete controlled test vehicle flights. - Complete final integration and checkout of guided test vehicles in preparation for flight testing. - Complete end-to-end system flight demonstrations. - Validate demonstrated system performance. - Transition program developed designs. ***FY 2013 Plans:*** - Modify booster adapter structure which mates standard Mk-114 booster clamp to missile body aft end. - Investigate new hybrid canister design with solid-wall section on forward end and corrugated side panels on aft end. - Analyze shock and fly-out requirements. - Perform minor airframe design modifications for canister fit and internal structure/composite skin strengthened to react to vertical launch loads. - Transition follow-on vertical launch system activities to the Navy leading up to two canister expulsion and booster separation test.			
Title: Collaborative Hypersonic Research (CHR) ***Description:*** The Collaborative Hypersonic Research (CHR) program will design, build, and demonstrate a tactical sized boost-glide hypersonic vehicle which will show direct traceability to a tactical long range strike weapon system capable of being launched from any 21 inch or larger booster system. The program will be flight experiment intensive and will leverage current	-	-	11.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
activities in HTV-2 and the Air Force/Australia HiFire program to develop a robust national modeling and simulation (M&S) framework. CHR flight experiments will establish a deeper foundation of data while proving out aero/thermal and guidance, navigation and control challenges. By incrementally tackling key technology areas while constantly updating the M&S capabilities, CHR will provide key information to the tactical, conventional prompt global strike (CPGS), and hypersonic communities. ***FY 2013 Plans:*** - Develop baseline designs to demonstrate necessary technologies traceable to a tactical system. - Evaluate baseline designs using M&S and some minimal ground testing. - Perform Military Utility Analysis.			
Title: VTOL (Vertical Take-Off and Landing) X-Plane ***Description:*** The VTOL (Vertical Take-Off and Landing) X-Plane program will demonstrate revolutionary VTOL systems development through a series of component and system ground and flight tests, at subscale and full scale, leading to full scale flight demonstration of key technologies. Program goals include flight speeds of greater than 250 knots, enhanced high/hot hover performance, improved edgewise rotor cruise performance, prop-rotor cruise efficiencies approaching propellers, hover-power loading at a minimum of 11 pounds thrust per horsepower, and a 20% improvement in empty weight fraction. Technologies will be pursued in four distinct research thrusts: performance, safety and survivability, supportability and availability, and collaboration and autonomy. The successful VTOL X-Plane would demonstrate the potential and mission utility of new technologies, and be a significant step toward closing current capability gaps in this class of air vehicles. Transition partners will include the branches of DoD operating vertical flight systems, including the Army, Navy, Marine Corps, Air Force and Special Forces. ***FY 2013 Plans:*** - Develop technology maturation plans. - Perform technology area specific value assessments and capability gaps analyses. - Initiate concept definition and preliminary design.	-	-	9.600
Title: Hypersonic Technologies ***Description:*** The goals of the Hypersonic Technologies program are to develop and demonstrate enabling technologies for 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. The program will improve understanding of long-range hypersonic flight through innovative ground-based testing, flight demonstrations, and modeling and simulation. Additionally, the program will demonstrate enabling technologies for future long-range hypersonic 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 high speed cruise and	-	-	38.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
re-entry vehicle applications. All efforts will be closely coordinated with the Office of Secretary of Defense Conventional Prompt Global Strike (CPGS) program office. Hypersonic Technology program results are planned for transition to the Air Force and the CPGS office. ***FY 2013 Plans:*** - Implement improvements in highly coupled hypersonic toolsets incorporating assessed uncertainties of key technologies from recent CPGS testing activities. - Refine hypersonic boost glide designs & technology applications including related ground and flight experiments based on recent test derived knowledge base improvements in aerodynamics, aerothermodynamics, and controls. - Improve high temperature materials base for hypersonic flight and re-entry vehicles applications through improved manufacturing, modeling, and ground and flight based testing. - Improve flight test range asset coordination including options for large scale space based telemetry collection. - Analyze alternative launch systems for enhanced long range hypersonic flight. - Refine and implement flight test regime for next generation long range hypersonic boost glide technology demonstrations.			
Title: Autonomous High Altitude Long Endurance (HALE) Refueling (AHR) ***Description:*** The Autonomous High Altitude Long Endurance (HALE) Refueling (AHR) program will demonstrate high altitude refueling between unmanned aircraft in an operational environment. The program uses NASA RQ-4 Global Hawk unmanned aircraft as surrogate platforms to inform the development of next generation HALE aircraft built around aerial refueling, which has proven so vital to manned military aviation. Specific challenges include precise control of limited flight performance aircraft under high-altitude conditions, redundant safe separation, and complex unmanned flight operations. The program will also promote the application of autonomy for better effectiveness, efficiency, and safety in challenging environments. The anticipated transition partner is the Air Force. ***FY 2011 Accomplishments:*** - Completed wind-tunnel evaluation of high-altitude drogue performance. - Validated end-to-end system design through hardware in the loop ground testing. - Completed component fabrication and aircraft structural modifications. - Completed in-flight characterization of wake flow fields. ***FY 2012 Plans:*** - Complete aircraft component installation and software validation. - Conduct flight tests and demonstrate repeatable refueling performance. - Conduct operationally stressing refueling demonstration.	13.900	5.068	-

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Complete data analysis and document feasibility of fully autonomous aerial refueling in challenging conditions.			
Title: Vulcan ***Description:*** The goal of the Vulcan program is to design, build, and ground test a pressure gain combustion (PGC) technology system that demonstrates a 20% reduction in specific fuel consumption for power generation turbine engines. PGC technology has been under development for more than a decade and considerable progress has been made in key enabling technology areas. The technology is believed mature enough to permit a dramatic new system capability. PGC, when combined with turbine engines, offers the ability to design a new class of hybrid turbine power generation engines and Mach 4+ air breathing propulsion systems. The Vulcan system consists of a full scale PGC, a compressor, and a turbine, and would have direct application to ship power generation and propulsion turbine engines, aviation turbine engines, high-mach air breathing engines, as well as commercial turbine engines of the same variety. This program is funded from PE 0602715E, Project MBT-03, Tactical and Strategic Energy Technology in FY 2012. Anticipated Service users include the Air Force and Navy. ***FY 2011 Accomplishments:*** - Conducted simulations to validate subsystem detailed designs. - Conducted risk reduction testing and demonstrations of key PGC component technologies and subsystems. - Matured and validated critical PGC enabling technologies and analytical tools. - Designed, procured and began assembly and instrumentation of a PGC module test rig.	45.000	-	-
Title: DiscRotor Compound Helicopter ***Description:*** The goal of the DiscRotor program was to design and demonstrate the enabling technologies required to develop a new type of compound helicopter capable of high-efficiency hover and high-efficiency, high-speed flight, with stable, continuous and reversible transition between these flight states. The aircraft concept featured a mid-fuselage disc with extendable rotor blades, and an aft swept wing. With the rotor blades extended and the disc rotating, the aircraft would operate like a helicopter with vertical take-off, efficient hover, controllable low speed flight and vertical landing. With the blades retracted, the aircraft would be capable of efficient wing-borne cruise at speeds exceeding any existing rotorcraft, 2-3 times that of a conventional helicopter. Specific objectives of the DiscRotor program included: demonstrating the feasibility of safely and repeatedly retracting/extending the blades into the disc in forward flight, characterizing the flowfield environment created by a disc-rotor, demonstrating disc-rotor enabling technologies, and correlating performance and loads and dynamics between high fidelity physics-based analytical predictions and wind tunnel testing to confirm capability to adequately design advanced rotorcraft configurations. Interested partners include the Army, Navy, Marines, Air Force, Coast Guard, and SOCOM. ***FY 2011 Accomplishments:*** - Conducted testing of a subscale rotor and fuselage in a hover test rig.	2.210	-	-

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Continued refinement of operational air vehicle configuration. - Completed critical design of 12 foot diameter large-scale extendable/retractable rotor model. - Validated DiscRotor conceptual approach, risk assessment, and definition of demonstrator requirements. - Validated high fidelity physics-based analytical capability to predict performance and loads and dynamics of advanced rotorcraft configurations. - Conducted wind tunnel testing of DiscRotor model. - Correlated analytical tools with wind tunnel results.			
Title: Mode Transition (MoTr) Demonstration ***Description:*** The Mode Transition (MoTr) Demonstration program aimed to ground test a turbine-based combined-cycle (TBCC) engine using hydrocarbon fuel. The MoTr program objective was to demonstrate transition from turbojet to ramjet/scramjet cycle to enable reusable, air-breathing, hypersonic flight. MoTr leveraged previous and on-going advances in air-breathing propulsion technology, including the Falcon Combined-cycle Engine Technology (FaCET) and the Air Force/DARPA High Speed Turbine Engine Technology Demonstration (HiSTED) program. The transition partner was to have been the Air Force. ***FY 2011 Accomplishments:*** - Completed design analysis of a TBCC engine model. - Completed critical design of primary testing modifications.	3.528	-	-
Accomplishments/Planned Programs Subtotals	234.389	98.878	174.316

D. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• Integrated Sensor is Structure: *Air Force PE 0305205F Project 675372F*	0.000	52.425	20.907	0.000	20.907	7.963	0.000	0.000	0.000	Continuing	Continuing
• Integrated Sensor is Structure-: *Air Force PE 0603203F Project 665A*	2.100	2.800	9.400	0.000	9.400	1.000	0.000	0.000	0.000	Continuing	Continuing
• LRASM: *Navy*	67.560	24.510	0.000	0.000	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
• Triple Target Terminator (T3): *Air Force*	8.930	27.050	41.730	0.000	41.730	0.000	0.000	0.000	0.000	Continuing	Continuing

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E. Acquisition Strategy

N/A

F. Performance Metrics

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

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	88.777	97.541	159.704	-	159.704	232.546	234.308	225.308	194.186	Continuing	Continuing
SPC-01: *SPACE PROGRAMS AND TECHNOLOGY*	88.777	97.541	159.704	-	159.704	232.546	234.308	225.308	194.186	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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.

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 novel propulsion/propellants, unique manufacturing processes; precision control of multi-payload systems, and payload isolation and pointing systems.

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B. Program Change Summary ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013 Base**	**FY 2013 OCO**	**FY 2013 Total**
Previous President's Budget	98.130	97.541	138.704	-	138.704
Current President's Budget	88.777	97.541	159.704	-	159.704
Total Adjustments	-9.353	-	21.000	-	21.000
• Congressional General Reductions	-0.499	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-8.328	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	2.000	-			
• SBIR/STTR Transfer	-2.526	-			
• TotalOtherAdjustments	-	-	21.000	-	21.000

Change Summary Explanation

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

FY 2013: Increase reflects expansion of space programs addressing access, domain awareness and new servicing technologies.

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Title: System F6 ***Description:*** The objective of the System F6 program is to demonstrate the feasibility and benefits of a satellite architecture wherein the functionality of a traditional "monolithic" spacecraft is replaced by a cluster of wirelessly-interconnected spacecraft modules. Each such "fractionated" module would contribute a unique capability, for example, computation and data handling, communications relay, guidance and navigation, payload sensing, or it can replicate the capability of another module. The fractionated modules would fly in a loose, proximate cluster orbit capable of semi-autonomous reconfiguration or a rapid defensive scatter/re-gather maneuver. Critical to this architecture is a robust, system-level approach to ensuring security, integrity, and availability, while implementing authentication and non-repudiation. While delivering a comparable mission capability to a monolithic spacecraft, System F6 significantly enhances architectural and programmatic adaptability and robustness-reducing risk through the mission life and spacecraft development cycle, enabling incremental deployment of the system, and enhancing survivability. The System F6 architecture provides valuable options to decision makers throughout the life cycle development of future space systems that are absent in present-day monolithic architectures. The System F6 program will culminate in an on-orbit demonstration of a multi-module space system incorporating the F6 Technology Package (F6TP) - a suite of technologies, components, and algorithms that enables semi-autonomous multi-body cluster flight and secure, distributed, real-time sharing of various spacecraft resources at the cluster level. Multiple versions	35.000	40.000	48.000

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

of the F6 Technology Package will be developed on the basis of open-source interface standards, software, and reference designs termed the F6 Developer's Kit. The on-orbit demonstration will be capable of accommodating one or more spacecraft payload modules supplied by a third-party mission partner. Residual capability to support future payloads with the existing on-orbit infrastructure will also remain following the demonstration, and the infrastructure can be upgraded for a perpetual on-orbit resource capability. The utility of the F6 architecture in low earth orbit (LEO) is significantly enabled by persistent broadband connectivity to the ground which allows resource sharing between space-based modules and terrestrial network nodes. A solution to enable high-availability, low-latency, persistent, high-bandwidth communications with LEO spacecraft will be developed in the course of the F6 program. The anticipated transition partner is the Air Force, though the architecture will have the ability to simultaneously accommodate payloads from multiple other partners including the Army and Navy. The resultant architecture is expected to significantly lower the barrier to entry and enhance competiveness of the national security space industrial base.

FY 2011 Accomplishments:
- Completed a series of value-centric satellite architecting wargames comparing traditional DoD acquisition processes vs. new analytic tools and metrics.
- Continued development of open-source interface standards, software, and reference hardware models for the F6 Developer's Kit (FDK).
- Conducted Preliminary Design Review for the persistent broadband terrestrial connectivity solution for LEO fractionated clusters.

FY 2012 Plans:
- Complete parametric model analyses and review of initial standards.
- Commence development of the F6 Tech Package (F6TP).
- Complete FDK software development and fabrication of prototype wireless transceivers.
- Release beta version of the FDK.
- Conduct preliminary design review for the F6TP.
- Release solicitation for demonstration spacecraft buses and launch vehicles.
- Perform end-to-end hardware-in-the-loop testing of the persistent broadband terrestrial connectivity solution for LEO fractionated clusters.
- Conduct Critical Design Review (CDR) for the persistent broadband terrestrial connectivity solution for LEO fractionated clusters.
- Take delivery of engineering model of the persistent broadband terrestrial connectivity solution for LEO fractionated clusters.

FY 2013 Plans:
- Complete final release of the FDK.
- Complete a fully-functional, polished, well-documented, user-friendly design tool for adaptable fractionated space systems.
- Conduct CDR for the F6 Technology Package.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Take delivery of the engineering development unit of the F6TP. - Take delivery of flight unit of the persistent broadband terrestrial connectivity terminal for LEO fractionated clusters. - Initiate procurement of spacecraft buses for F6 on-orbit demonstration.			
Title: Airborne Launch Assist Space Access (ALASA)*	5.000	12.000	29.000

Description: *Formerly Horizontal Launch

The goal of the Airborne Launch Assist Space Access (ALASA) program is to mature and demonstrate technologies for cost effective, routine, reliable, horizontal access to low earth orbit (LEO). ALASA seeks improvements in cost, responsiveness, flexibility, and resilience with a single approach. ALASA will enable small satellites to be deployed to orbit from an airborne platform, allowing performance improvement, reducing range costs, and flying more frequently, which drives cost per pound down. The ability to relocate and launch from virtually any major runway around the globe reduces the time needed to deploy a satellite system. Launch point offset permits essentially any possible orbit direction to be achieved without concerns for launch direction imposed by geography. Finally, launch point offset allows the entire operation to be moved should a particular fixed airfield become unavailable due to natural phenomena or other issues. Challenges include, but are not limited to: in-air separation of aircraft and orbit-insertion launch stages, development of alternatives to current range processes, control of weight and margin under a hard gross weight limit, and achieving a cost of $1 million, including range support costs, to deploy satellites on the order of 100 lb. The anticipated transition partner is the U.S. Air Force.

FY 2011 Accomplishments:
- Conducted market/business case analysis for horizontal launch concepts.
- Analyzed alternative infrastructure options including cost considerations.
- Determined preliminary mission architecture and technology trade space to enable horizontal launch.

FY 2012 Plans:
- Perform conceptual design of selected architecture focusing on key technology gaps.
- Initiate preliminary design.
- Develop and mature related enabling and enhancing technologies.

FY 2013 Plans:
- Complete initial test plans for flight demonstrator.
- Complete risk management plan.
- Conduct preliminary design review and select enabling and enhancing technologies for incorporation into system concepts.
- Conduct critical design review and initiate detailed design.

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Integrate selected enabling and enhancing technologies on launch assist aircraft.			
Title: Space Domain Awareness (SDA)	9.000	18.000	29.000

Description: The goal of the Space Domain Awareness (SDA) program is to develop and demonstrate an operational framework and responsive defense application to enhance the availability of vulnerable space-based communications resources. SDA will investigate revolutionary technologies in two areas: 1) advanced space surveillance sensors to better detect, track, and characterize space objects, with an emphasis on deep space objects, and 2) space surveillance data processing/data fusion to provide automated data synergy, to increase space domain awareness, overall space safety of flight, and ultimately to allow space operators to make informed, timely decisions. Current space surveillance sensors cannot detect, track, or determine the future location and threat potential of small advanced technology spacecraft in deep space orbits, where a majority of DoD spacecraft are located. Additionally, servicing missions to geosynchronous (GEO) orbits will require exquisite situational awareness, from ultra high-accuracy debris tracking for mission assurance at GEO orbits to high resolution imaging of GEO spacecraft for service mission planning. The SDA program will leverage data fusion and advanced algorithms developed under the Space Surveillance Telescope (SST) program, as well as seek to exploit new ground-breaking technologies across the electromagnetic spectrum and utilize already existing sensor technology in non-traditional or exotic ways, to bring advanced capabilities to the space domain. SDA will correlate a wide range of operational support and space system 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 system integrity. The potential transition customer is the Air Force.

Efficient collection of data for SDA is crucial to controlling costs. SDA will demonstrate new approaches to collection of data utilizing a variety of collection modalities, ranging from fusion of observations from amateur astronomers, to evaluation of sparse aperture imaging techniques. The first sparse aperture demonstration is Galileo. This effort will develop technology to image a Geosynchronous Earth Orbit (GEO) satellite from the ground. Galileo will utilize fixed mobile telescopes, each with adaptive optics and a guide star, to create multiple baselines that can be used to reconstruct the image through an inverse Fourier transform. The concept is similar to existing astronomic interferometers, except Galileo will extend the basic interferometric technology to utilize fiber optic transport of light between each telescope to match the optical path length instead of the traditional evacuated light tubes. Technical challenges include: controlling thermal effects and disperation within the fiber to properly interfere the light from the two telescopes, and precisely measuring the distance between the fixed and mobile telescope systems.

FY 2011 Accomplishments:
- Surveyed existing systems and identified critical technology gaps.
- Initiated data fusion modeling effort to determine limitations of currently developed algorithms.

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Completed investigations into using a dynamic track graph algorithmic approach to achieve timely cataloging of breakups and collisions. - Evaluated high resolution passive imaging of GEO satellites using incoherent intensity correlation imaging. ***FY 2012 Plans:*** - Conduct intensity correlation imaging study final review. - Develop prototype next-generation collaborative space information fusion center to provide a revolutionary approach to integrating, collaborating and visualizing complex space system and environmental data, enabling operators to make informed decisions to protect critical space capabilities; concepts to be explored include intuitive applications and adaptive understanding. - Develop architecture for low cost space situational awareness (SSA) data sources. - Develop additional SSA data integration algorithms to incorporate cyber initiatives into the space information fusion center. - Expand the concept of dynamically tasked sensors so that the entire SSA network is continuously optimized and capable of responding to any highlighted space threat. - Develop requirements and designs for the Galileo mobile telescope and fiber control system. - Develop plans to integrate the Galileo mobile telescope and fiber control into a single proof-of-concept demonstration. ***FY 2013 Plans:*** - Demonstrate the advantages of a having a collaborative network of users with access to data from numerous distributed sensors over the traditional sensor-centric architecture. - Demonstrate intuitive applications and adaptive understanding capabilities of the next-generation space information fusion center. - Build, test, and deploy the Galileo mobile telescope system. - Build, test, and deploy the Galileo fiber control system. - Integrate the Galileo systems and perform an imaging campaign for a 10cm spatial resolution image of an 11 Mv GEO satellite.			
Title: Space Surveillance Telescope (SST) ***Description:*** The Space Surveillance Telescope (SST) program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. A major goal of the SST program is to develop the technology for large curved focal surface array sensors to enable an innovative telescope design combining high detection sensitivity, short focal length, wide field of view, and rapid step-and-settle to provide orders of magnitude improvements in space surveillance. This capability will enable ground-based detection of un-cued objects in deep space for purposes such as asteroid detection and space defense missions. The Air Force will participate in the DARPA funded developmental testing of SST and then take over operation of SST as a sensor in the Air Force Space Surveillance Network. A memorandum of agreement has been established with Air Force Space Command (AFSPC) for transition. The program is also	10.840	10.041	10.204

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
investigating expanding the demonstration of the telescope to explore detection and tracking of broader classes of space objects under different orbital regimes, and the impact of observations from different environments. In addition, the program will investigate data fusion and advanced algorithms for correlation of unknown objects. SST is expected to generate a large number of uncorrelated targets (UCTs), and new methods will need to be employed to rapidly characterize and attribute the new objects. Furthermore, the program will investigate methods which combine observations from disparate sensors (such as optical and radar installations) to more rapidly, accurately, and completely provide knowledge about UCTs, as compared to the existing system where no data fusion is employed. Where appropriate, SST will investigate new concepts which would provide complementary or further advances in ground-based deep space object detection and characterization. This data fusion effort is called Ibex. ***FY 2011 Accomplishments:*** - Finished optics integration on site. - Completed integration of sensor subsystem into telescope. - Integrated camera and data processing subsystems at site. - Completed initial alignment of full SST system ("First Light"). - Completed site acceptance testing of telescope. - Integrated facilities control software for fine focus and alignment. - Investigated data processing algorithms to enhance contribution of SST data to space situational awareness (SSA). - Investigated data fusion capabilities to enhance SSA through use of multiple optical sensors for multi-static observations and track handoffs. - Commenced packaging of available imagers to construct backup wide field camera for the system. - Developed UCT handling procedure with AFSPC to convey SST search results to the Space Surveillance Network in timely and useable manner. ***FY 2012 Plans:*** - Complete final technical demonstration of SST system performance; evaluate demonstration activities and SST mission functionality. - Conduct systems requirement review for the Ibex data fusion effort. - Conduct Ibex preliminary and critical design reviews. - Develop initial Ibex capability packages. - Perform first of two Ibex capability demonstrations.			

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Conduct preliminary investigation of locating the SST in more operationally relevant location in order to perform a more in-depth demonstration. ***FY 2013 Plans:*** - Refine Ibex capability packages. - Conduct second Ibex demonstration. - Transition Ibex services to users. - Complete investigation and planning for optimal SST location.			
Title: Phoenix* ***Description:*** *Formerly Manned Geostationary Earth Orbit Servicing (MGS) To date, servicing operations have not been conducted on spacecraft beyond low earth orbit (LEO). A large number of national security and commercial space systems operate at GEO altitudes, furthermore, many end-of-life or failed spacecraft drift without control through portions of the GEO belt, creating a growing hazard to operational spacecraft. Technologies for servicing of spacecraft with the expectation such servicing would involve a mix of highly autonomous and remotely (i.e., ground-based) teleoperated robotic systems have been previously pursued. The Phoenix servicing program will build upon these legacy technologies, tackling the more complex GEO environment. The program seeks to repurpose high value long life components on existing satellites in GEO, in full collaboration and cooperation with existing satellite owners, utilizing commercial ridealong capability to send small packaged systems into GEO for use in upgrading, fixing, repairing, and enhancing the repurposed components. Key challenges include transportation and orbital maneuvering, robotic systems and integration, and extravehicular tool requirements. The anticipated transition partner is the U.S. Air Force. ***FY 2011 Accomplishments:*** - Identified and evaluated flight/ground servicing experience, satellite failures, and candidate servicing missions. - Defined preliminary mission architecture and technology trade space to enable robotic GEO servicing missions. ***FY 2012 Plans:*** - Perform conceptual mission design and feasibility studies. - Perform conceptual design of selected demonstration mission, focusing on system architecture and key technology gaps. ***FY 2013 Plans:*** - Prepare preliminary design of robotic servicing system. - Develop payload orbital delivery systems (PODS) designs for commercial satellite ridealong. - Initiate flight scale build of first PODS. - Initiate development and build of robotic servicing components.	4.000	12.500	28.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiate six degree of freedom testbed on ground; begin virtual system testing. - Build first prototype of sensor suite for guidance and control on servicer.			
Title: SeeMe* ***Description:*** *Formerly Single Wafer Integrated Femto Satellites (SWIFT) The U.S. Army, U.S. Air Force, intelligence community, and other potential users require affordable support to the tactical warfighter via space. The goal of the "SeeMe" program is to demonstrate the ability to get near-real-time, i.e., no older than ~90 minutes, images directly to individual users' handheld devices from space. This will be accomplished via a very low cost constellation of inexpensive, disposable small satellites routinely and inexpensively put in orbit through low cost horizontal (airborne) launches. The current methodology for satisfying imagery needs from space is to build multipurpose systems with very high reliability and long life, at very high costs, and launch them on expensive vertical launch boosters. In most cases, commercial or military, the time to deliver an already built space Intelligence, Surveillance, Reconnaissance (ISR) system suitable to meet tactically desired ground sample distance is on the order of 20+ months, and the data delivery mechanism is typically more than several days (and up to weeks) to the end user. SeeMe intends to radically shorten the entire cycle: ground development time, launch cadence, and on-orbit request-to-image-delivery time. The anticipated transition partner is the U.S. Air Force and the U.S. Army. ***FY 2012 Plans:*** - Conduct trade study of available technologies and investment opportunities. - Initiate concept design. - Perform detailed system trade between a low cost launch alternative and metrics associated with constellation size and altitude. - Evaluate technologies for direct satellite to handheld device capabilities. - Perform evaluation of a multitude of manufacturing processes and technologies from non-aerospace disciplines to achieve 10x cost reduction. - Select specific satellite architecture for hardware instantiation as prototypes. ***FY 2013 Plans:*** - Execute technical integration options for hardware level development. - Demonstrate applicability to commercial production environment. - Begin to show prototype functionality in actual hardware. - Validate a high quantity low cost production run for a representative constellation that would support ISR capability directly to the warfighter.	-	5.000	15.500
Title: Membrane Optic Imager Real-Time Exploitation (MOIRE)	15.400	-	-

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Membrane Optic Imager Real-Time Exploitation (MOIRE) program enabled the technology for very large aperture optics for space platforms. MOIRE's diffractive optics significantly reduced the optical tolerances required to create images, enabling very large optical elements to be created. MOIRE demonstrated the manufacturability of large membranes, large structures to hold the optics tight and flat, and also demonstrate the secondary optical elements needed to turn a diffractive optic (such as fresnel zone plate) into a wide bandwidth imaging device. MOIRE ended with a technology demonstration that significantly reduces the risk of using these types of optics for flight development. The anticipated transition partner is the Air Force. ***FY 2011 Accomplishments:*** - Conducted payload preliminary design review for a 10 m demonstration system. - Conducted system concept design review for a 10 m demonstration at geo-synchronous orbit. - Defined the requirements for brassboard development for ground testing of a 5m diffractive lens system. - Completed optics specifications for procurement for the 5m lens system. - Finished integration and test of a small scale (20cm) diffractive optical element for an on-orbit demonstration. - Launched and demonstrated the deployment and on-orbit imaging performance of a risk reducing small scale (20cm) diffractive optical element.			
Title: XTIM ***Description:*** XTIM examined exploiting X-ray pulsars for navigation and time uses independent of, and supplemental to, GPS. The program studied using these sources to calculate position and absolute time, and then broadcasting this information to users either on the ground or in space as a method to enhance navigation solutions. This reference data could also be used to update the GPS constellation ephemerides and timing with limited or no ground support, and could provide an alternative timing source as a checksum for GPS receivers to insure detection of spoofing or sophisticated jamming attacks. ***FY 2011 Accomplishments:*** - Designed a geosynchronous orbit demonstration mission to be launched aboard an evolved expendable medium class launch vehicle. - Performed an X-ray beam line test of the brass board design to demonstrate feasibility of X-ray detection and timing. - Performed an electron background rejection measurement of the brass board design to demonstrate feasibility of the geosynchronous background mitigation concept.	4.537	-	-
Title: Front-end Robotics Enabling Near-term Demonstration (FREND) ***Description:*** The Front-end Robotics Enabling Near-term Demonstration (FREND) program developed and demonstrated robotic manipulator technologies designed to allow interaction with geosynchronous orbit-based military and commercial spacecraft,	5.000	-	-

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
extending their service lives and permitting satellite refueling, repair, refurbishment, repositioning or retirement. The program also examined possible solutions for classes of debris in low earth orbit (LEO). ***FY 2011 Accomplishments:*** - Conducted technology and utility trade studies to model the LEO debris problem, identify significant risks to operational assets, and determine possible technological solutions. - Developed debris remediation conceptual designs.			
Accomplishments/Planned Programs Subtotals	88.777	97.541	159.704

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	181.118	150.286	111.008	-	111.008	104.665	101.412	95.412	88.843	Continuing	Continuing
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	77.179	62.053	36.466	-	36.466	43.188	29.642	37.642	32.095	Continuing	Continuing
MT-15: *MIXED TECHNOLOGY INTEGRATION*	103.939	88.233	74.542	-	74.542	61.477	71.770	57.770	56.748	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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 project will also address thermal management, navigation and positioning technology challenges.

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

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

B. Program Change Summary ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	197.098	160.286	111.499	-	111.499
Current President's Budget	181.118	150.286	111.008	-	111.008
Total Adjustments	-15.980	-10.000	-0.491	-	-0.491
• Congressional General Reductions	-1.002	-			
• Congressional Directed Reductions	-	-10.000			
• Congressional Rescissions	-2.586	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-7.319	-			
• SBIR/STTR Transfer	-5.073	-			
• TotalOtherAdjustments	-	-	-0.491	-	-0.491

Change Summary Explanation

FY 2011: Decrease reflects reductions for the Section 8117 Economic Adjustment, internal below threshold reprogrammings, rescissions and the SBIR/STTR transfer.

FY2012: Decrease reflects reduction to new starts.

FY 2013: Decrease reflects minor repricing.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012

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

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	77.179	62.053	36.466	-	36.466	43.188	29.642	37.642	32.095	Continuing	Continuing

A. Mission Description and Budget Item Justification

The MicroElectroMechanical Systems (MEMS) and Integrated Microsystems Technology program is a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those used to make microelectronic devices, MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale power and actuation systems as well as microscale components that survive harsh environments. The microfluidic molecular systems effort will develop automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules for tailored sequence analysis to monitor environmental conditions, health hazards and physiological states. Thermal management technologies will develop heat resistant thermal layers to provide efficient operation for cooling electronic devices. Another focus in micro technologies is to improve navigation, position and timing capabilities for uncompromised navigation and positioning in today's dynamic military field of operations.

The major technical focus areas of the MEMS and Integrated Microsystems programs contained in this project are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) chemical reactions on chip; 5) electromechanical signal processing; 6) analytical instruments; 7) thermal management; and 8) navigation and positioning technologies.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Thermal Management Technologies (TMT) ***Description:*** The goal of the Thermal Management Technologies (TMT) program is to explore and optimize new nanostructured materials and other recent advances for use in thermal management systems. The overall goal of the program is to insert breakthrough materials and structures at all layers of DoD systems, and enable higher power densities, increased performance, and improved efficiency. Innovative research is underway to go beyond evolutionary thermal management systems. Modern, high-performance heat spreaders, which use two-phase cooling, are being developed to replace the copper alloy spreaders in conventional systems. Enhancing air-cooled exchangers by reducing the thermal resistance through the heat sink to the ambient, increasing convection through the system, improving heat sink fin thermal conductivity, optimizing and/or redesigning the complimentary heat sink blower, and increasing the overall system (heat sink and blower) coefficient of performance is another thrust of this program. Another element of this effort is focused on novel materials and structures that can provide significant reductions in the thermal resistance of the thermal interface layer between the backside of an electronic device and the next layer of the package, which might be a spreader or a heat sink. The TMT program is an aggregation of: Thermal Ground Plane	27.797	19.936	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
(TGP), Microtechnologies for Air-Cooled Exchangers (MACE), Nano Thermal Interfaces (NTI) and Active Cooling Modules (ACM) technology research. Technology will be inserted through DoD industrial firms into future DoD systems. ***FY 2011 Accomplishments:*** - Delivered sample high thermal conductivity substrates to DoD labs (Army Research Laboratory, Naval Surface Warfare Center and the Air Force Research Laboratory) for testing against DoD application needs. - Designed customized substrates for customer-selected insertion opportunities. - Designed and built prototype active cooling module elements that demonstrate active cooler benefits. - Delivered enhanced heat exchangers for insertion demonstrations on mobile platforms. - Demonstrated reliable, reworkable nanostructured thermal interface materials based on nanotubes, nanoplates and nanosprings with reduced thermal resistance. ***FY 2012 Plans:*** - Insert TGP substrates to demonstrate improvements in Gallium Nitride Power amplifiers, High-Power transmit/receive modules, high-density electronic systems, avionics modules, and other opportunities enabled by lightweight, flexible, highly-conductive heat spreaders. - Complete insertion demonstrations for enhanced heat exchangers, and initiate transitions to platforms. - Demonstrate 10x improvements over state of the art for reworkable thermal interface materials. - Demonstrate high active cooling modules for efficient operation of cooled electronic devices.			
Title: Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T) ***Description:*** The Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T) program is developing technology for self-contained chip-scale inertial navigation and precision guidance. This technology promises to effectively mitigate dependence on Global Positioning System (GPS) or any other external signals, and enable uncompromised navigation and guidance capabilities. The program will enable positioning, navigation and timing functions without the need for external information updates by employing on-chip calibration, thereby overcoming vulnerabilities which arise in environments where external updates are not available such as caves, tunnels, or dense urban locations. The technologies developed will enable small, low-power, micro-gyroscopes capable of operating in both moderate and challenging dynamic environments; chip-scale primary atomic clock standards; and on-chip calibration systems for error correction. Advanced micro-fabrication techniques allow a single package containing all the necessary devices (clocks, accelerometers, gyroscopes, and calibration mechanisms) to be incorporated into a volume the size of a sugar cube. The small size, weight and power (SWaP) of these technologies and their integration into a single package responds to the needs of guided munitions, unmanned aerial vehicles (UAVs) and individual soldiers. The Micro PN&T program is an aggregation of Integrated Primary Atomic Clock, Navigate Grade Integrated Micromachined Gyroscopes, Micro Inertial Navigation Technology, Information Tethered Microscale Autonomous Rotary Stages, Micromachined Rate Integrating Gyroscopes, Single-Chip Timing and Inertial Measurement Unit, Primary and Secondary Calibration on Active	33.698	42.117	36.466

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

Layer, and Chip-Scale Combinatorial Atomic Navigator. The technology is expected to transition through industry and existing DoD transition partnerships with the Services.

To achieve the low SWaP necessary for guided munitions, UAVs, and personal navigation applications, the technologies in the MicroPN&T program will have to push the limitations of integration and performance in current MicroElectroMechanical systems (MEMS) technologies. Unprecedented levels of precision will be required to meet the stringent demands of the military environment. New architectures for devices will be developed that will leverage advances in fabrication techniques in order to increase stability and performance of a MEMS structure. Applied research for this program is funded within PE 0602716E, Project ELT-01.

FY 2011 Accomplishments:
- Transitioned chip-scale atomic clock effort to the Army's ManTech program.
- Demonstrated a 25cc cold atom micro-primary standard package that consumes only 150 Megawatts and has a time loss of 157 nanoseconds after one day.
- Demonstrated 4m @ 4hrs navigation accuracy during walking along a closed perimeter.
- Demonstrated 5cc nuclear magnetic resonance gyroscope that consumes 20mW of power and has a Angle Random Walk of 0.01 degrees per square root of hour and bias drift of 0.05 degrees per hour.
- Demonstrated 0.2 cc micro-stage rotating at 10 deg/sec and has a run time of 100 hrs.
- Demonstrated trapping 10^5 to 10^6 ions in the miniature ion trap 25 cc in volume consuming 150mW.
- Conducted independent government testing of chip-scale atomic clocks and micro-gyroscopes on a P-3 Orion and T-6B aircraft.

FY 2012 Plans:
- Develop design architecture for low-cost, small size rate integrating gyroscopes to provide direct measurement of orientation and angular velocity.
- Identify fabrication method to co-fabricate clocks and inertial sensors into a single low power package for navigation microsystems either monolithically or with disparate materials.
- Demonstrate three-dimensional microfabrication techniques for rate integrating gyroscopes that are compatible with large scale manufacturing.
- Model internal and external sources of error for inertial devices.
- Identify self-calibration techniques to compensate for long-term drift.

FY 2013 Plans:
- Demonstrate a microsystem rate integrating gyroscope to provide directly measured orientation angle and angular velocity.
- Demonstrate a microsystem that combines a functional timing and inertial measurement unit.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Demonstrate the co-fabrication of an inertial sensor and a calibration stage to enable integration of error correction technologies on the same stage. - Demonstrate a fabrication technique that allows for the integration of timing and inertial measurement unit into a small package. - Use models for internal and external sources of error to develop on-chip calibration algorithms. - Develop an architecture for chip-scale combinatorial atomic navigator. - Demonstrate combinatorial physics for fast startup time, high accuracy inertial devices.			
Title: MEMS Exchange ***Description:*** The MEMS Exchange program provided MEMS fabrication technology services to a broad user base, including all levels of industry and academia in support of Army, Navy, Air Force, and other DoD requirements. A major goal of the effort was to ensure self-sustained operation of the MEMS Exchange without further DARPA sponsorship. This program aided in the establishment of an accessible infrastructure for low or medium volume production of MEMS-enabled products for DoD applications. ***FY 2011 Accomplishments:*** - Implemented quality control efforts to achieve higher reliability in manufacturing. - Optimized process cost efficiencies by increased marketing of MEMS Exchange capability. - Improved self-sufficiency by providing a higher value to program users by improved yield and lower manufacturing costs.	1.100	-	-
Title: Chip-Scale Technology ***Description:*** The goal of the Chip-Scale Technology effort was to enhance microsystems performance by developing efficient on-chip vacuum pumps that meet application requirements for chip-scale micro-gas analyzers. Chip-Scale Technologies have the potential to improve the critical performance of microsystems such as micro mass spectrometers, nanoscale detectors, RF resonators, and vacuum microelectronic components. This program developed a high-performance integrated low-power (< 2 W) microscale (< 15 cm3) pumping (< 10-6 Torr) capability, and is transitioning via industrial performers. ***FY 2011 Accomplishments:*** - Demonstrated a microfabricated mid-vacuum turbomolecular pump with a 10^5 compression ratio, exceeding 10^-5 Torr while consuming < 1 W. - Demonstrated Knudsen pump, requiring only 0.4 Watts to evacuate from 760 Torr to 7 Torr. - Demonstrated Micro-scale sputter-ion pump evacuating down to 10^-2 Torr while consuming no more than 0.4 Watts. - Demonstrated single-stage microfabricated rough pump with a compression ratio of 4.6 - this is the highest recorded value for a MEMS pump.	7.414	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	**PROJECT** MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Demonstrated meso-scale rough pump (23 cm^3) capable of sustaining mass-flow of 11 standard cubic centimeters per minute with 3.1 Watts of power.			
Title: Nano-Electro-Mechanical Computers (NEMS) ***Description:*** The goal of the Nano-Electro-Mechanical Computers (NEMS) program was to develop nanoscale mechanical switches and gain elements integrated intimately with complementary metal-oxide semiconductor switches. The program also developed mechanical gain elements to enable very low-noise, high-frequency amplifiers for low-power, low-noise analog signal processing. This technology will facilitate production of electronics that are less susceptible to electromagnetic pulse attacks and is transitioning into DoD systems via industrial program performers. ***FY 2011 Accomplishments:*** - Demonstrated digital building blocks for 4-bit and 8-bit mechanical microcontroller - finite state machines, counters, latches, registers, memory arrays, clocks, adders, and multipliers. - Demonstrated automated design flow, logic synthesis, design rule checking and formal verification of complex relay-based very large scale integration circuits. Microcontroller design with 12,000 relays required only 5% hand-tuned custom logic design to minimize impact of mechanical delays. - Demonstrated 10^7 cycles to failure when operating under realistic conditions. - Demonstrated mixed-signal mechanical components - analog to digital converters, digital to analog converters, compressors, ring oscillators, real-time clock, and class E power amplifiers. - Demonstrated reduced power consumption (3x) and footprint (2x) of Field Programmable Gate Array/mechanical switch hybrid technology without loss of speed - designed and fabricated in collaboration with a major FPGA manufacturer.	7.170	-	-
Accomplishments/Planned Programs Subtotals	77.179	62.053	36.466

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, **RDT&E Project Justification:** PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	**PROJECT** MT-15: *MIXED TECHNOLOGY INTEGRATION*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
MT-15: *MIXED TECHNOLOGY INTEGRATION*	103.939	88.233	74.542	-	74.542	61.477	71.770	57.770	56.748	Continuing	Continuing

A. Mission Description and Budget Item Justification

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'.

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).

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) ***Description:*** The COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) program goal is to realize the fundamental performance potential of the resonant fiber optic gyro in combination with bandgap optical fiber (BGOF), ultra-stable compact lasers, phase conjugate elements, and silicon optical benches: a compact ultra-stable gyro for absolute reference applications.	10.501	10.087	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	**PROJECT** MT-15: *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
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. This program will transition via industry. ***FY 2011 Accomplishments:*** - Reduced loss in BGOF to 0.6 decibels per kilometer (dB/km). - Demonstrated laser with laser noise suppression electronics on lab bench. - Developed initial Silicon optical bench interface for gyro based band gap optical fiber. ***FY 2012 Plans:*** - Develop bandgap optical fiber process to realize 500m lengths of polarizing bandgap fiber with less than 0.5 dB/m loss and off axis polarization suppression. - Demonstrate low noise laser in package suitable for integration with final 4 in diameter gyro. - Demonstrate bandgap optical fiber gyro in the laboratory using a 6 in coil with path to 4 in coil.			
Title: Gratings of Regular Arrays and Trim Exposures (GRATE) ***Description:*** 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 22 nm for today's commercial products. Due to challenging patterning requirements and complex circuitry, the costs of circuit design and verification, lithography tools and masks, and testing costs have increased exponentially and are unaffordable for low-volume manufacture of application specific integrated circuits (ASICs) for military electronics. Consequently, 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 fabrication techniques and 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 2011 Accomplishments:*** - Designed a set of logic and memory cells optimally suited to 1-D patterning at the 32 nanometers technology node using silicon test data directly from the fab. - Demonstrated photolithography techniques for line widths < 32 nm by triple patterning and ~12.5 nm by using directed self-assembly (DSA) techniques. - Completed initial exploration and evaluation studies of 1-D computer aided design tool development for extension to the 14 nm technology node.	7.425	9.000	6.415

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Completed preliminary 1-D fabrication demos including various circuit elements making use of 1-D specific process extensions. - Demonstrated linewidths < 90 nm for analog devices using existing lithography tools and matched speed performance of state-of-the-art devices. ***FY 2012 Plans:*** - Demonstrate grating-based design and fabrication, including experimental verification of desired patterns. The demonstration vehicles will be logic/memory "standard cells" and high speed RF devices in state-of-the-art Complimentary Metal-Oxide Semiconductor (CMOS) technologies. - Develop the "trim/stitch" processes for digital designs at 32 nm. - Fabricate analog devices with > 350 GHz performance. - Create a design targeted at 14nm technology for CMOS using basic library tools from phase 1. ***FY 2013 Plans:*** - Fabricate 1-D digital design at the 22 nm node. - Demonstrate > 300 GHz performance for 1-D Silicon Germanium transistor circuit. - Transition and make the analog 1-D design and fabrication available to the DoD user community via a multi-project wafer run.			
Title: Maskless Direct-Write Nanolithography for Defense Applications ***Description:*** 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, Integrated Circuits (ICs) in small lots 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 affordable incorporation of state-of-the-art semiconductor devices in new military systems, and allow for the cost-effective upgrade of legacy military systems. ***FY 2011 Accomplishments:*** - Designed, built and tested Generation 2 Column. This column increases beam current and wafer throughput by 2X at reduced blur. - Designed, built and tested a 10 m/s rotary stage to hold six 300 mm wafers. - Integrated electron beam column and rotary stage demonstrator platform. - Fabricated a Dynamic Pattern Generator (DPG) structure comprising more than 1 million electrostatic lenslets. - Designed, built and tested wafer metrology system. - Designed, built and tested DPG data preparation system and data path.	17.609	15.000	15.000

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	**PROJECT** MT-15: *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Designed, built and tested Generation 3 Column. This column iteration further increases beam current and reduces blur. ***FY 2012 Plans:*** - Demonstrate system-level lithography achieving a resolution of <100 nanometers (nm) and a throughput of one 300mm-wafer-level-per-hour. - Develop and demonstrate a sensitive photoresist with acceptable performance for the 32 nm node. - Design and fabricate a second generation DPG alleviating processing challenges. - Demonstrate and characterize layer-to-layer alignment and swath-to-swath stitching. - Design and build final 100-150 kilo electron Volt e-beam column. ***FY 2013 Plans:*** - Design and build a high-throughput linear stage production platform. - Demonstrate system-level lithography achieving a resolution of 45 nm and a throughput of 5-7 300mm-wafer-levels-per-hour. - Make available Maskless Nanowriter lithography technology for incorporation into the DoD Trusted Foundry and other DoD foundries.			
Title: Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) ***Description:*** The Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) program primarily addresses the passive imaging needs for multi-band, wide field of view (FOV) and high-resolution imaging for ground and near ground platforms. The AWARE program aims to solve the technological barriers that will enable wide FOV, high resolution and multi-band camera architectures by focusing on four major tasks: High space-bandwidth product (SBP) camera architecture; Small pitch pixel focal plane array architecture; Broadband focal plane array architecture; and Multi-band focal plane array architecture. The AWARE program will advance integration of technologies that enable wide field of view and high resolution and multi-band cameras, including the technologies demonstrated in the related AWARE program in PE 0602716E, Project ELT-01. AWARE aggregates the following programs: Lambda Scale (formerly NIRD), Broadband (formerly PT-SQUAD), Multi-Band (formerly DUDE), and Wide Field of View (formerly MOSAIC). The integration of the technologies will demonstrate subsystems such as focal plane arrays (FPAs) and cameras. ***FY 2011 Accomplishments:*** - Demonstrated broadband detection from 0.5-5.0 micrometer (μm) with Noise Equivalent Temperature Difference (NETD) < 100 metre Kelvin (mK) at an operating temperature of 200 K using 30 μm photonic crystal array. - Fabricated Long Wave Infrared (LWIR) 5μm detectors with performance and operability exceeding program goals. - Demonstrated a 1280x720, 5 μm pixel Readout Integrated Circuit (ROIC) with a 75% warm probe yield. This will lead to low cost FPAs based on large number of die per wafer and excellent ROIC yield.	33.217	15.946	12.198

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	R-1 ITEM NOMENCLATURE PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	PROJECT MT-15: *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Established low temperature process for integrated dual band (LWIR and SWIR) IR detectors. - Demonstrated independent functionality with integrated LWIR and SWIR detectors. ***FY 2012 Plans:*** - Develop and apply 10 µm pitch plated indium bump processes to electrically active ROIC wafers for hybridization to 512 x 512, 30µm photonic crystal pillar detector arrays. - Develop photonic crystal FPA process scaling to 15µm pitch for 1.5K x 1k & 2k x 2k arrays. - Start fabrication of 4:1 SWIR to LWIR device and demonstrate 4:1 architecture. - Develop 720p 5 µm LWIR camera. - Develop and fabricate 2k x 2k ROIC for LWIR camera to be assembled and demonstrated in 2013. ***FY 2013 Plans:*** - Fabricate 15µm pitch 1536x1024 FPA with Integrated Dewar Cooler Assembly (IDCA). - Demonstrate integrated LWIR/SWIR camera (640x 512 for LWIR and 1024x1280 for SWIR). - Demonstrate 2k x 2k, 5 µm LWIR pixel camera under brownout conditions.			
Title: Excalibur ***Description:*** The Excalibur program will develop high-power electronically-steerable optical arrays, with each array element powered by a fiber laser amplifier. These fiber-laser arrays will be sufficiently lightweight, compact, and electrically efficient to be fielded on a variety of platforms with minimal impact to the platform's original mission capabilities. Each array element will possess an adaptive-optic capability to minimize beam divergence in the presence of atmospheric turbulence, together with wide-field-of-view beam steering for target tracking. With each Excalibur array element powered by high power fiber laser amplifiers (at up to 3 kilowatts per amplifier), high power air-to-air and air-to-ground engagements will be enabled that were previously infeasible because of laser system size and weight. In addition, this program will also develop kilowatt-class arrays of diode lasers which will provide an alternate route to efficiently reaching mission-relevant power levels, and they will test the ultimate scalability of the optical phased array architecture. Excalibur arrays will be conformal to aircraft surfaces and scalable in size and power by adding elements to the array. By defending airborne platforms such as unmanned aerial vehicles against proliferated, deployed, and next-generation man-portable air-defense systems (MANPADS), Excalibur will enable these reconnaissance platforms to fly at lower altitude and obtain truly persistent, all-weather ground reconnaissance despite low-lying cloud cover. Proliferated and emerging threats will be evaluated for the potential of developing a near-term capability utilizing a single high-power fiber laser amplifier. Further capabilities include multichannel laser communications, target identification, tracking, designation, precision defeat with minimal collateral effects as well as other applications. The Excalibur program will also develop efficient high-power laser amplifier arrays based on coherent or spectral beam-combining. The potential of these arrays to scale to tactical power levels (100 kilowatt class) will be investigated. These laser	17.821	18.200	20.420

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	**PROJECT** MT-15: *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
amplifier arrays will be designed to work in tandem with the core laser components developed under the Excalibur program in PE 0602702E, Project TT-06. In addition prototype High Energy Laser Counter Measure (HELCM) systems will be developed to enable a near-term capability for low-altitude self-defense against MANPADS. This technology will transition via industry. ***FY 2011 Accomplishments:*** - Demonstrated phase locking and atmospheric compensation of turbulence on a 7-kilometer range using a 7-element optical phased array. - Performed functional-defeat testing of representative proliferated and deployed MANPADS threats. - Demonstrated a phased array of eight 500-W fiber laser amplifiers. - Developed conceptual designs for complete high-energy laser countermeasure (HELCM) systems for both functional and structural kill that are compact and light enough to be deployed on Reaper-class UAVs. ***FY 2012 Plans:*** - Complete the design, fabricate and procure the components for a coherently or spectrally combinable array of 21 array elements, each fed by a compact 1-kW fiber laser amplifier. - Demonstrate a 7-kW 7-element fiber-amplifier laser array using coherent-combining with a diffractive optical element, spectral-combining with a dispersive grating, and coherent-combining using a 2-D array with adaptive optics for tip/tilt correction. - Initiate development of ancillary HELCM open architecture subsystems (command, threat warning/ laser-quality declaration, lightweight pod). ***FY 2013 Plans:*** - Demonstrate beam combining (coherent or spectral) of twenty-one 1-kW fiber laser amplifiers. - Demonstrate coherent combining of a 19-element 2-D optical phased array with a combined power of 21 kW and tip/tilt adaptive optics. - Develop and demonstrate prototype HELCM open-architecture subsystems in a laboratory environment. - Initiate the development of a proactive search capability for HELCM systems.			
Title: Low Cost Thermal Imager - Manufacturing (LCTI-M) ***Description:*** The Low Cost Thermal Imager - Manufacturing (LCTI-M) effort builds upon previous manufacturing and imaging work and will develop a pocket-sized, manufacturable, and practical thermal imager at a price point that allows them to be provided to large numbers of warfighters. Availability of very low cost and small form-factor infrared (IR) cameras will facilitate new techniques and applications that could provide the decisive edge needed in modern battlefields. These cameras will allow a soldier to have practical thermal imaging capability for locating warm objects (e.g., enemy combatants) in darkness. The small size, weight and power (SWaP) thermal camera will be integrated with a handheld device such as a cell phone with network capability for tactical intelligence, surveillance and reconnaissance. In order to achieve this goal, breakthroughs will be required	5.357	20.000	20.509

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
in low-cost thermal imagers manufactured using wafer scale integration, vacuum packaging, low cost optics and low-power signal processing. By the end of the program, the imager chips will be fully integrated with a low-cost processor and optics. The camera will have wireless connectivity to integrate video display with cell phones or PDAs. U.S. Army PEO Soldier Sensors and Lasers (SSL), PM Optics USMC and industry will be the transition partners. ***FY 2011 Accomplishments:*** - Preliminary requirement analysis for the camera architecture completed. - Phase I efforts by industry performers initiated to develop and fabricate components required for the low cost ($500) thermal imager. - Developed a mini portable thermal camera as the initial benchmark and demonstration for size, weight and power. - Handheld cellular phone platform selected as the portable display and computing engine. ***FY 2012 Plans:*** - Develop and review camera design and overall architecture compatible with cell phone platform. - Develop and evaluate wafer-scale vacuum packaging of 17-micron bolometers with infrared-transparent windows. - Develop low cost infrared optics and wafer scale camera electronics. ***FY 2013 Plans:*** - Develop and evaluate wafer-scale vacuum packaging of 12-micron bolometers with infrared-transparent windows. - Evaluate low cost infrared optics and wafer scale camera electronics. - Demonstrate integrated bolometer-based thermal imager chips with integral packaging. - Demonstrate connectivity and display on a handheld device (cell phone).			
Title: Hemispherical Array Detector for Imaging (HARDI) ***Description:*** The Hemispherical Array Detector for Imaging (HARDI) program exploited the benefits of a hemispherical imaging surface. The key concept 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 simple lens to produce a wide field of view, small form factor camera that operates over a wide spectral range (400 nm to 1900 nm). 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. Patterning of these materials on the hemispherical surface has been demonstrated by utilizing maskless laser lithography. This program will transition to DoD systems through a demonstration of an array prototype developed by industrial contractors. ***FY 2011 Accomplishments:*** - Demonstrated a prototype 1 megapixel, 1 cm radius hemispherical focal plane array for the spectral range of 400-1900 nm.	2.870	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603739E: *ADVANCED ELECTRONICS TECHNOLOGIES*	**PROJECT** MT-15: *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Developed a lens specifically designed for the hemispherical focal plane array. - Demonstrated a prototype f/1.4 camera with a 120 degree field of view with high reliability.			
Title: Radio Frequency Photonic Technology (RPT) ***Description:*** The Radio Frequency Photonics Technology (RPT) program developed components and microsystems to revolutionize deployed signal intelligence (SIGINT) gathering capabilities. The radio frequency (RF) spectrum contains innumerable friendly and adversarial signals of interest including: voice and data communications, electronic signatures, and navigation information. Conventional electronic systems are challenged in detecting weak signals in the presence of strong ones (low-linearity) across a broad range of frequencies (narrow-band). The RPT program efficiently captured all RF signals of interest by developing broad-band (>10 gigahertz) high-linearity (>70 decibels dynamic-range) optical components and microsystems. RPT enabled linear broadband microsystems such as remote links, channelizers, and analog-to-digital converters (ADCs). The RPT program reduced susceptibility to electronic attack, increased the probability-of-intercepting (POI) adversaries on their first-pulse transmission, and increased information awareness 1000-fold. This technology will transition via industry. ***FY 2011 Accomplishments:*** - Developed photodiodes capable of 27.4 decibels per milliwatt RF power with a 15 GHz bandwidth. - Demonstrated a photonic link with >120 dB/Hz2/3 SFDR from 9-17 GHz, a dynamic range 4 times better than a state-of-the-art electronics link.	9.139	-	-
Accomplishments/Planned Programs Subtotals	103.939	88.233	74.542

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	200.593	261.606	237.859	-	237.859	244.941	245.805	253.746	253.523	Continuing	Continuing
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	56.914	52.503	16.487	-	16.487	8.237	8.632	8.632	11.510	Continuing	Continuing
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	87.841	88.476	122.669	-	122.669	121.083	120.291	130.291	129.730	Continuing	Continuing
CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*	8.400	32.030	42.840	-	42.840	53.520	54.210	55.000	55.000	Continuing	Continuing
CCC-CLS: *CLASSIFIED*	47.438	88.597	55.863	-	55.863	62.101	62.672	59.823	57.283	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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.

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.

The goals of the Secure Information and Network Systems project are to develop and test emerging computer, communications, and network systems where the impact of the systems and the vulnerabilities of the systems are not kinetically based. Network Security technologies arising from other projects will be further identified, developed, integrated, and tested.

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*

B. Program Change Summary ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	219.809	296.537	266.783	-	266.783
Current President's Budget	200.593	261.606	237.859	-	237.859
Total Adjustments	-19.216	-34.931	-28.924	-	-28.924
• Congressional General Reductions	-1.117	-			
• Congressional Directed Reductions	-	-34.931			
• Congressional Rescissions	-10.442	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.000	-			
• SBIR/STTR Transfer	-5.657	-			
• TotalOtherAdjustments	-	-	-28.924	-	-28.924

Change Summary Explanation

FY 2011: Decrease reflects reductions for the Section 8117 Economic Adjustment, internal below threshold reprogrammings, rescissions and the SBIR/STTR transfer.

FY 2012: Decrease reflects reductions for unsustained growth and reduction to new starts.

FY 2013: Decrease reflects the completion of command and control programs such as Resilient C2 and Deep Green and decreases in the classified program area, offset by additional communications and cyber work.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**PROJECT** CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	56.914	52.503	16.487	-	16.487	8.237	8.632	8.632	11.510	Continuing	Continuing

A. Mission Description and Budget Item Justification

Military operations since the end of the Cold War show 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 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. These will provide the commander with 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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: ZETA ***Description:*** The ZETA program is exploring the aspects of novel physical devices, concepts, and techniques that leverage quantum physics for information technology. Research in this area has the ultimate goal of demonstrating information technology components with radical improvements in power efficiency and/or computational power relevant to military applications and opportunities. The program will transition via industrial performers. ***FY 2011 Accomplishments:*** - Continued experimental and theoretical validation of key device physics and qubit assumptions. ***FY 2012 Plans:*** - Demonstrate improved performance of quantum devices. - Detailed planning for small-scale demonstration of key physical devices. ***FY 2013 Plans:*** - Perform small-scale demonstration of key physical devices.	29.000	36.000	16.487
Title: Resilient Command and Control (RC2) ***Description:*** The Resilient Command and Control (RC2) program is developing a general framework and set of critical mission assurance capabilities to enable Commanders and their staffs to manage the array of C2 systems and architectures (sensor, communications, and information processing) used to conduct operations. These adaptive, resilient C2 resource planning and	17.760	16.503	-

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
re-planning capabilities will ensure mission success in the face of C2 system outages. Specific technologies being developed under RC2 include advanced analysis, visualization, and planning tools to provide Commanders and their staffs with a dashboard that enables the following capabilities: (1) attain and maintain situation awareness of the C2 architectures; (2) understand mission impact of outages; and (3) realign the C2 systems to ensure the Commander's intent. The tools and technologies that result from RC2 will enable operators to detect anomalous behavior via intuitive information displays; assess business function impact, including second- and third-order effects; and re-plan how the system can be used to achieve organizational goals and priorities. Transition is planned to U.S. Pacific Fleet (PACFLT). ***FY 2011 Accomplishments:*** - Conducted experiments with users at PACFLT. - Participated in an operational exercise (Terminal Fury 11) and demonstrated the collaborative workflow and content classification tools for chat and message traffic at a single node. ***FY 2012 Plans:*** - Enhance collaborative workflow and content classification tools by adding visualization capabilities and domain specific knowledge to support the intel operational domain. - Conduct experiments with users at PACFLT. - Participate in an operational exercise (Terminal Fury 12) and demonstrate the enhanced collaborative workflow and content classification tools in two operational domains. - Investigate early transition opportunities with Navy.			
Title: Deep Green ***Description:*** Deep Green is a next-generation, battle command and decision support technology that combines 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 has radically reduced the time needed to plan and execute military operations and will reduce the number of staff officers needed in an operations center. Deep Green automatically infers the commander's intent and produces a plan from the commander's hand-drawn sketches to facilitate rapid option creation, and plan recognition and understanding capabilities ensure the commander's intent is fully represented in the system. Deep Green technologies transitioned to the Army. ***FY 2011 Accomplishments:*** - Extended Deep Green to support multi-echelon operations, including Deep Green systems at brigade and battalion levels coordinating among themselves. - Demonstrated fully-functional, multi-echelon, full-spectrum battle command technology. - Extended the Deep Green system to support both mid-intensity conflict and counter-insurgency operations.	5.631	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**PROJECT** CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Conducted virtual field exercises with Deep Green at military training facilities.			
Title: Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis) ***Description:*** The Urban Leader Tactical Response, Awareness and Visualization (ULTRA-Vis) program developed an integrated, soldier-worn situational awareness system that allows ground forces to display iconic representations of blue force locations, tactically relevant targets, and coordinated actions and effects. The icons are geo-registered on the battlefield and viewed from each warfighter's perspective using a see-through, head-mounted display. The system enabled soldiers to conduct non-line-of-sight combat operations and maintain situational awareness while on the move. Information management protocols support the dissemination of tactical information to enable a soldier to direct weapons platforms for real-time collaboration without overload. ULTRA-Vis technologies allows soldiers to selectively receive and visualize critical combat information using existing, low-bandwidth soldier voice and data radios. ULTRA-Vis has empowered ground forces 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 under evaluation by the Air Force Special Operations Command (AFSOC), the Army, and the Marines. ***FY 2011 Accomplishments:*** - Created Cursor on Target XML-formatted data displays and information management tools. - Made improvements in function and performance of all sub-components. - Refined the green optical waveguide design to reduce optical distortions and increase efficiency, reducing power consumption. - Enhanced the head-tracking algorithms to support infrastructure-free head tracking using computer vision and Kalman filtering. - Began integration of ULTRA-Vis testbeds to evaluate system functionality and capabilities.	4.523	-	-
Accomplishments/Planned Programs Subtotals	56.914	52.503	16.487

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012

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

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	87.841	88.476	122.669	-	122.669	121.083	120.291	130.291	129.730	Continuing	Continuing

A. Mission Description and Budget Item Justification

The success of military operations depends on timely, reliable, secure, and synchronized dissemination of command and control and relevant situational awareness information to every military echelon. While wired communications and networks are fairly well developed, providing assured high-bandwidth mobile wireless capabilities that match or exceed commercial wired infrastructure is needed to meet the demands of military users. The goal of the Information Integration Systems project is to develop and demonstrate technologies that will provide effective communications to U.S. forces. Approaches to this goal include developing technologies that increase network capacity and scaling, enhance spectrum efficiency in congested spectrum, tolerate network degradation, provide man-made and natural electromagnetic interference mitigation, defeat network reconnaissance and surveillance, counter denial of service and other threats, and autonomously move relevant information from the cloud to the edge.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Military Networking Protocol (MNP)	9.750	21.268	10.308

Description: The Military Networking Protocol (MNP) program will create architectures, protocols and network controllers to enhance security and operation of military networks. MNP technologies will enforce military user authentication, manage military network traffic and automatically configure military networks. By enforcing military user authentication, military network protocols will provide full attribution of every military device and track each device's network flows to provide full attribution down to the individual source of bad/erroneous data or malicious activity. MNP prioritization schemes will be controlled by the military commanders at various echelons to address changing mission requirements. MNP technologies will transition to DISA and/or the military Services.

FY 2011 Accomplishments:
- Initiated the detailed design of the selected MNP architecture and protocols and built prototype network controllers.
- Completed initial testing and down-select to a single MNP architecture, protocol and network controller design set.
- Coordinated with DISA and the Services to foster program participation and to develop a transition plan for MNP technologies.

FY 2012 Plans:
- Conduct an initial system test and verification of the MNP architecture and protocols.
- Continue the refinement and design of the selected MNP architecture, protocols and network controllers.
- Increase the scale of the MNP test-bed for the final test and demonstration.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Coordinate with DISA and the Services to continue program participation and to finalize a transition plan and/or memorandum of agreement for MNP technology. ***FY 2013 Plans:*** - Conduct capstone demonstration for MNP system. - Coordinate with Services for use in their information assurance/computer network defense exercises.			
Title: Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS)	20.596	18.257	15.565
Description: The Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS) program goals are to develop and demonstrate technologies and system concepts that will enable densely deployed radio networks to compensate for limitations of the physical layer of a low-cost wireless node. WNaN/AWNS networks will manage node configurations and the topology of the network to reduce the demands on the physical and link layers of the network. The technology created by the WNaN/AWNS effort will provide reliable and available battlefield communications at low system cost. This program will also improve the hardware, firmware, and software to allow the integration of the Joint Tactical Radio System (JTRS) Soldier Radio Waveform (SRW) for backward interoperability to legacy communication systems. AWNS is also investigating the integration of Multi-User Detection (MUD) and Multiple-Input Multiple Output (MIMO) technology into the WNaN radio platform to position these technologies for transition into the WNaN radio node. In addition, this effort will investigate Wireless Distributive Computing (WDC), Content Based Access (CBA), and smart antenna technology to enhance the network and node ability to understand the operating environment, mission concept of operations, and node responsibilities to assist in data processing, information dissemination, and accomplishment of military mission objectives. In addition, this program will develop a low-cost handheld/body wearable wireless node that can be used to form high-density adhoc networks and gateways to the Global Information Grid. This program will also develop robust networking architecture(s) and network technologies/processes that will exploit high-density node configurations. AWNS technology is planned for transition to the U.S. Army. ***FY 2011 Accomplishments:*** - Demonstrated spectrum efficiency and utilization in experimentation and simulation. - Demonstrated ability to integrate and install Type 2 security architecture in radio nodes. - Completed simulations of mobile ad hoc wireless network performance in networks of 1,000 nodes. - Integrated Mobile Networked MIMO (MNM), Multi-User Detection (MUD), and Soldier Radio Waveform (SRW - EW mode) prototypes into radio nodes. - Participated in U.S. Army's Network Integrated Evaluation (NIE).			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Explored ability of radio node to perform multi-purpose applications and alternative platform applications. ***FY 2012 Plans:*** - Integrate MUD and MIMO into the system so all waveform types are available for various communication conditions to improve network performance. - Integrate Wireless Distributed Computing (WDC), Content Based Access (CBA), and associated networking functions to support transformative application functionality. - Develop real-time network performance monitoring, remote agent control for WNAN for C4ISR applications, and advanced security gateway and guard micro chips and modular security architecture. - Integrate smart antenna capabilities into radio nodes. - Develop algorithms and performance capabilities to enable network scaling to > 1,000 nodes. - Perform experiments utilizing transformational applications within the WNaN node. - Perform network integration evaluations. ***FY 2013 Plans:*** - Demonstrate capability to integrate transformation applications in an integrated network environment. - Complete development of radio nodes capable of MIMO, MUD, WDC, Dynamic Spectrum Awareness, and related technologies to improve network performance, and increase network scalability without increasing spectrum need. - Demonstrate real-time network performance monitoring, enhanced network architecture to support networking amongst sensors, robots, soldiers, Unmanned Air Vehicles and Remotely Piloted Vehicles, and an advanced security gateway using modular security architecture. - Demonstrate network scaling to support brigade-level utility > 1,000 nodes.			
Title: Communications Under Extreme RF Spectrum Conditions (CommEx) ***Description:*** The Communications Under Extreme RF Spectrum Conditions (CommEx) program will develop signal detection and reasoning technology that will allow radios to recognize interference and jamming attacks and then adapt to maintain communications, even in the presence of cognitive jammer attacks and dynamic interference of multiple cognitive network interactions. The program will develop models of adversary, commercial, and friendly cognitive radios and implement those models in a "reasoner" that assesses, in real time, the current and future dynamics of the communications network. Core technologies for operation in highly dynamic and/or high jamming to signal environments will be developed to include: automated jamming waveform forensics; RF Environment assessment (time, space, frequency, polarization); technologies for addressing known attack strategies and interference properties; and antenna, RF, signal processing, modulation, and network optimization technology. Based on predictions of the level of communication success compared to mission communication requirements, the "reasoner" within the cognitive radio will choose waveform selections/configurations that best achieve mission objectives. The "reasoner" will include the capability to analyze and select optimum frequency, waveform, and network configurations	6.500	10.000	13.265

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

during all aspects of a mission, to include initial alert, ingress, mission, and exfiltration. The design effort will lead to new radio communication architectures, more robust radio communication networking, and better understanding of selection amongst interference avoidance and interference suppression strategies.

This program also seeks to enable communication between dispersed and distributed emitters and receivers to provide a multiplier in capacity for both locating emitters and assessing effectiveness of an electronic attack. The CommEx technology is planned for transition to the U.S. Army, Air Force, and Navy.

FY 2011 Accomplishments:
- Developed algorithms to measure cognitive radio jammers and communication network behaviors that sufficiently characterize state space and behavior.
- Established baseline sensor performance requirements.
- Developed efficient model structures of communication links, interference networks, essential metrics, and transforms.
- Defined what resources are available to handheld, vehicular, airborne, or shipboard communication platforms and determined the level of performance able to be achieved for each platform.
- Developed efficient distributed algorithms and implemented hardware prototypes for carrier frequency offset and frame synchronization.
- Developed efficient algorithms for channel estimation, computation and distribution of network information; designed the associated protocols.
- Initiated development of smart antenna technology that can provide deep nulls for use against jammers.
- Initiated development of Government test-bed that will be used to evaluate approaches being developed by performers.

FY 2012 Plans:
- Demonstrate algorithms to measure cognitive radio jammers and communication network behaviors that sufficiently characterize state space and behavior.
- Integrate live hardware into the detailed experiments to assure that dynamic range, realistic multipath and clutter, and implementation-specific simulations are analyzed with sufficient rigor to assure performance in live hardware.
- Perform experiments and simulations that model legacy waveforms and interference sources not previously seen by the system.
- Develop hardware, firmware, and software using CommEx technologies, and corresponding application programming interfaces and drivers in the radio to understand and control system performance.
- Demonstrate ability of smart antenna technology to create deep nulls.
- Emulate hardware, firmware, and software using prototyping technologies, and develop corresponding application programming interfaces and drivers to understand and control system performance.

Exhibit R-2A, **RDT&E Project Justification:** PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Demonstrate distributed Multiple-Input Multiple-Output (MIMO) techniques for spatial beam control, interference mitigation, and communication range extension on testbeds. ***FY 2013 Plans:*** - Integrate CommEx technology into operational platforms for transition experimentation. - Execute evaluations and demonstrations using actual systems in military environments.			
Title: Computational Leverage Against Surveillance Systems (CLASS)* ***Description:*** *Previously part of the CommEx program. Commercial Test and Measurement equipment has advanced greatly with the emergence of sophisticated cellular and wireless local area network technology and can be used to intercept, analyze and exploit our military communications signals. Building upon technologies investigated under the COMMEX Program, the Computational Leverage Against Surveillance Systems (CLASS) program seeks new ways to protect our signals from increasingly sophisticated adversaries and to do so in a way that can be maintained as technology advances. Three different techniques are being developed: 1) Waveform Complexity uses advanced communications waveforms that are difficult to recover without knowledge and understanding of the signals itself; 2) Spatial Diversity uses distributed communications devices and the communication environment to disguise and dynamically vary the apparent location of the signal; 3) Interference Exploitation makes use of the clutter in the signal environment to make it difficult for an adversary to isolate a particular signal. The objective of the program is to make modular communications technology that is inexpensive to incorporate in existing and emerging radio systems (<$100 incremental cost) but pushes adversaries to need more than 1,000x our processing power - "supercomputer" level processing power. Technologies from this program are planned to transfer to the U.S. Army's Communications - Electronics Command. ***FY 2011 Accomplishments:*** - Began investigating spatial diversity technology approaches. - Initiated design of the system architecture to combine novel waveforms, special diversity techniques and interference mitigation approaches to enable anti-geolocation. - Initiated development of the CLASS technology test bed. ***FY 2012 Plans:*** - Initiate development of waveform complexity and interference exploitation technologies. - Initiate the integrated circuit system integration process. - Complete test bed development and evaluate the performance of candidate technologies. ***FY 2013 Plans:*** - Integrate hardware and firmware technology into volume integrated circuits.	2.500	15.000	18.200

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Develop test and application driver software for CLASS technology. - Initiate development of modular CLASS products.			
Title: Content-Based Mobile Edge Networking (CBMEN)* ***Description:*** *Formerly known as Cloud to the Edge The goal of this program is to provide tactical warfighters operating at the edge with interactive, on-demand access to relevant information and a greater ability for real-time sharing of new operational content. This content can include images, video, maps, and databases. Ubiquitous access to relevant situational awareness and command and control information throughout the battle space is a key objective. Advances in key technologies are enabling high-capacity communications to the edge. However, the current centralized or regional storage and dissemination of information presents security, reliability, and capacity challenges in identifying and distributing relevant information to users at the edge. Commercial industry has developed approaches to the autonomous dissemination of high demand information by using distributed servers and advanced networking and information database technologies, combined with highly-reliable fixed networking infrastructure with embedded complex information exploitation tools. This program will leverage commercial capabilities to develop and demonstrate the technologies and prototype systems in networking, servers, and information dissemination techniques to enable efficient, and robust content distribution using dynamic, mobile, ad hoc military networks. Capabilities from this effort will transition to the DoD. ***FY 2012 Plans:*** - Develop base and objective metrics for scenarios and simulation development for program evaluation and analysis. - Develop software architectures for distributed data dissemination and technologies for dynamic networks. - Begin development of hardware and software integrated environments to demonstrate CBMEN technologies. - Begin development of key enabling technologies. ***FY 2013 Plans:*** - Develop extended small unit scenarios for simulation and demonstration. - Extend CBMEN software architecture for security and efficiency. - Integrate hardware and software products to demonstrate CBMEN technologies in small unit scenario. - Demonstrate limited content applications in a dynamic small unit mobile environment.	-	10.000	21.831
Title: Mobile Hot Spots ***Description:*** Communications requirements are growing exponentially due to the proliferation of high-data rate sensors (video), UAVs, and the emergence of the Soldier/Marine as both an operator and a sensor. Available spectrum is static and this data growth has created a 100-1,000x mismatch of data needs and available network capacity. Mobile Hot Spots will provide an analog to the commercial wired solution to exploding high bandwidth requirements that relies on a hierarchical approach using	-	10.000	17.100

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
core networks, regional/neighborhood distribution networks, and distributed access points. This program will develop the high data rate mobile communications technologies that are required to close the capacity gap and create spectrally efficient, and secure wireless technologies by exploiting advances in high-frequency millimeter wave and optical communications technologies. This effort will leverage commercial off the shelf short range, high speed communications access portals and scalable high data rate networking technologies. Trade-offs between scaling capacity, high data rate, communications overhead, system overhead (size, weight, and power), and mobility will be addressed. The Mobile Hot Spots program is targeted to transition to the Army and Marine Corps Expeditionary Forces. ***FY 2012 Plans:*** - Develop hardware and networking architectures for regional and local reliable, high capacity / high speed networks. - Develop physical layer, data layer, and network layer security solutions. - Initiate development of technologies for short range, high data rate networks. ***FY 2013 Plans:*** - Explore hardware, software, and waveform options in a network topology to include unmanned aerial systems, soldiers, and mobile platforms. - Develop methods to support spectrally efficient, high capacity activity in the communication networks. - Develop Hot Spot service interfaces to high demand applications. - Initiate security solution technology development.			
Title: Fixed Wireless at a Distance ***Description:*** Unlike commercial wireless communications, the military cannot count on a set of secure, fixed cell towers to establish wireless networks capable of receiving and distributing large amounts of data from distributed sources. Rather, such communication must rely on approaches such as balloons and temporary communication towers that have a high logistical burden and are extremely vulnerable. Building upon technologies investigated under other programs in this project, the Fixed Wireless at a Distance program will overcome these limitations by developing a re-locatable, long-range (10-100s of km) communication infrastructure that provides high-capacity (10s of Mbps) data links from within a protected space. The key innovation in this program is the use of a large number of rapidly deployable, distributed, ground-based antenna arrays that can form a coherent aperture for directional transmission and reception of information to/from tactical wireless networks. Program challenges include the fundamental limits (power and extent) of transmitter gain as well as the rapid and practical deployment of the ground-based arrays. When completed, the Fixed Wireless at a Distance program will extend the reach of tactical communication systems by 10X without the need for vulnerable and costly infrastructure. This technology is planned to transition to the Services. ***FY 2013 Plans:*** - Assess the fundamental limits of transmitter gain for a distributed ground-based wireless network.	-	-	10.100

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiate assessment of ground-based array to determine the required characteristics (number or antennas, spatial diversity, power) to enable 10X improvement in the range of tactical communication systems. - Develop concepts for rapidly deploying and re-deploying antenna arrays.			
Title: Advanced RF Mapping ***Description:*** One of the key advantages on the battlefield is the ability to actively sense and manipulate the RF environment, enabling secure communications as well as effectively mapping and manipulating the adversary's communications in ways that defy their awareness, understanding, or response. Current approaches for dealing with RF are emitter-based, with the signal processing techniques focused on array and time based processing for each emitter. As the RF environment becomes more complex and cluttered, the number of strategic assets and commensurate signal processing inhibits effectiveness and sustainability to sense and manipulate at the precision (time, frequency, and space) required for effective action. To address these shortfalls, the Advanced RF Mapping program will develop and demonstrate new concepts for sensing the RF environment based on distributed rather than emitter-based collection. These concepts take advantage of the proliferation of RF devices (radios, cell phones) on the battlefield. To use these devices effectively, the program will develop new algorithms that can map the RF environment with minimal communication load between sensors. It will also develop approaches for exploiting our precise knowledge of the RF environment and the distributed proximity of the RF devices to provide secure communications for our warfighter as well as to infiltrate or negate our adversaries' communications networks. For example, if synchronizing distributed elements to <10 picosecond is achievable, coherent RF power projection at UHF frequencies from distributed devices would be possible. Building upon technologies investigated under other programs in this project, the Advanced RF Mapping program will enable both offensive and defensive operations in complex RF environments. Advanced RF Mapping technology is planned to transition to the Services. ***FY 2013 Plans:*** - Establish baseline capabilities for RF collection from distributed devices in complex RF environments. - Initiate the development of algorithms for exploiting distributed RF collections into a full environmental map of frequency and space as a function of time. - Begin assessment of feasibility of synchronization of distributed elements to provide precision RF effects.	-	-	10.300
Title: Highly Networked Force ***Description:*** A highly networked and enabled force increases efficiency, effectiveness, and safety while reducing cost by making the right information available at the right time to every person and system that needs it. Accomplishing this depends on providing reliable wireless communications to all U.S. forces, platforms, and devices in all phases of conflict. The Highly Networked Force program seeks to overcome key limitations of current technology to realize the fully network-enabled force by addressing issues such as: lack of coverage due to operation in challenged locations or loss of relays or links; lack of capacity due to inefficient	-	-	6.000

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
allocation of scarce spectral resources; lack of connectivity due to networks that cannot keep up with the high rate of change; and lack of expected service due to uncoordinated management of sub-networks and gateways. Technologies developed under this program will be transitioned to the Services. ***FY 2013 Plans:*** - Investigate methods to improve end user coverage through cooperation between overlapping heterogeneous networks or communication systems, and through new relay and physical layer designs. - Investigate potential for sharing spectrum between radar and communication systems and develop architectures for spectrum sharing between multiple cooperating systems. - Investigate new routing, naming, and networking mechanisms optimized for highly dynamic wireless environments. - Develop and analyze architectures for coordinated enterprise-level management of networks and gateways.			
Title: Optical & RF Combined Link Experiment (ORCLE) ***Description:*** 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 Network system, called 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 Air Force. ***FY 2011 Accomplishments:*** - Improved and tested FSO communications terminals that use adaptive optics (AO) to increase the coupling efficiency of received laser light, while reducing overall received power variations. - Developed and tested an optical modem and forward error correction (FEC) system that, combined with the Optical Automatic Gain Control (OAGC), demonstrated greatly improved receiver sensitivities. - Completed build and began testing a high-speed multifunction hybrid router capable of delivering over 10 Gbps per channel while providing node discovery, Mobile Ad Hoc Network (MANET) formation, differentiation of services, and retransmission of lost packets.	19.070	3.951	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**PROJECT** CCC-02: *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Began assembly and installation of prototype systems on three aircraft and two ground terminals for data distribution as well as battlefield command and control experiments. ***FY 2012 Plans:*** - Execute final testing of a 4 node network (3 air nodes and one ground node) to demonstrate hybrid high data rate FSO/RF and advanced network capabilities that provide information data rates sufficient for current military needs and mission requirements. - Validate the ability to provide the warfighter with low latency information for command and control as well as Intelligence, Surveillance, and Reconnaissance (ISR) requirements. - Demonstrate network instantiation and user interfaces to allow high data rate command and control at multiple levels. - Demonstrate the data exfiltration capability by transmitting data from the Blue Devil Block 2 Airship operating at an altitude of 25,000 feet to a ground node positioned at a distance greater than 50 km from the Airship. - Complete transition of the technology to the Air Force/Big Safari.			
Title: Network Enabled by WDM-Highly Integrated Photonics (NEW-HIP) ***Description:*** The Network Enabled by WDM-Highly Integrated Photonics (NEW-HIP) program facilitated building or upgrading military aircraft and other aerospace platforms with a wavelength division multiplexed (WDM) single-mode fiber-optic networking infrastructure. NEW-HIP has many capabilities that are well beyond those of currently used copper- and multi-mode-fiber-based technologies. Originally, the program focused on specific technologies for application on the Navy's EA-6B Prowler aircraft; however, the program was broadened to focus on technologies to provide advanced capabilities to a multitude of military aircraft. The technologies developed under this program will be incorporated into military aircraft, including tactical aircraft, UAVs, wide-bodied aircraft, and rotorcraft. ***FY 2011 Accomplishments:*** - Continued development of the key optoelectronic digital and analog networking components with respect to performance, size, weight, power, and environmental requirements. - Conducted packaging and environmental testing of the key optoelectronic digital networking components. - Supported a Navy study to investigate the application of NEW-HIP technology to the surface and subsurface fleet. - Investigated the application of NEW-HIP to other tactical platforms, such as the Navy H-60 Helicopter, the Air Force F-22, and the Army Apache Helicopter.	4.998	-	-
Title: Analog Logic ***Description:*** The Analog Logic program developed and demonstrated architectures, designs, and development tools for implementing computational functions in analog circuitry to overcome performance limitations inherent in digital designs. This program applied 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	7.650	-	-

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
manufacturing variances. The Analog Logic program built and demonstrated an analog-only signal processing capability with no local oscillator, down-conversion, or analog-to-digital conversion. The goal was to achieve a 10 times reduction in gate count, a 1024 Point Fast-Fourier Transform (FFT) with 8 bits equivalent dynamic range, and functional performance within 0.5dB of digital performance. Further, the program investigated the system-level impact of Analog Logic on other embedded processing problems as well as the feasibility of creating programmable embedded processing solutions in this technology. This program will transition to both Industry and NSA. ***FY 2011 Accomplishments:*** - Demonstrated 1024-point FFT integrated circuit with 10.6 bits of measured dynamic range and >50x reduction in power consumption over state-of-art FFT implementations. - Demonstrated an FFT-based convolution engine with 10-bit programmable coefficient resolution, which is capable of realizing arbitrary filter transfer functions. - Demonstrated analog memory cells with 6-bits of information storage capacity per cell.			
Title: Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) ***Description:*** The Mobile Networked Multiple-Input/Multiple-Output (MIMO) (MNM) program pursued MIMO communication systems, which have the potential to increase data rates by 10-50 times those of current systems. MIMO uses multiple antennas to create parallel channels in the same frequency band, thereby increasing spectral efficiency. This effort demonstrated the MNM capability under dynamic urban Non-Line-of-Sight multipath channel conditions where conventional techniques are degraded. This effort also advanced MIMO technology development and performed field demonstrations of mobile ad hoc networks (MANETs), culminating in the development of a wideband form-factor system for use in tactical edge devices, such as troops, vehicles, and robotics. The MNM technology is planned for transition to the Army. ***FY 2011 Accomplishments:*** - Designed, built, tested, and demonstrated MIMO capabilities in a handheld, body-wearable, and other form-factors of multichannel radio that utilizes high volume, low cost commercial off-the-shelf RF circuits, narrowband tuning filters, and dual-core digital signal processors. - Demonstrated MIMO capability in a wideband small form-factor system in urban, rural, airborne, and shipboard terrain. - Performed network demonstration of MNM in handheld unit in a fieldable form-factor. - Demonstrated range enhancement and RF power efficiencies due to MIMO.	4.483	-	-
Title: Mobile Ad Hoc Interoperability Networking GATEway (MAINGATE) ***Description:*** Building upon gateway technology developed under the WNaN and Future Combat Systems (FCS) Communications program, the Mobile Ad hoc Interoperability Networking GATEway (MAINGATE) program developed the next generation Network	12.294	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**PROJECT** CCC-02: *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Centric Radio System (NCRS) with additional capabilities. MAINGATE enables heterogeneous groups of radios to be integrated into a heterogeneous network tolerant to high latency and packet loss. The technologies developed for the program permit affordable, tactical, real-time, and high-fidelity video, data, and voice services for deployment in a networked environment to support tactical operations in maneuvering or dismounted operations for line-of-sight (LOS) and beyond-line-of-sight (BLOS) communications, both on the move (OTM) and at the halt (ATH). The resulting MAINGATE system and capability is under evaluation for possible transition for the U.S. Army. ***FY 2011 Accomplishments:*** - Enhanced the MAINGATE system units by expanding RF spectrum coverage, increasing user data rate, and improving link reliability. - Conducted in-theater and CONUS field evaluations of units performing Intelligence, Surveillance, and Reconnaissance/ Command and Control (ISR/C2) networking radio interoperability.			
Accomplishments/Planned Programs Subtotals	87.841	88.476	122.669

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
• NAVY PE 0603251N: *2777: Highly Integrated Photonics (HIP) Naval Networking*	0.000	0.000	20.000	0.000	20.000	0.000	0.000	0.000	0.000	Continuing	Continuing

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**PROJECT** CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*	8.400	32.030	42.840	-	42.840	53.520	54.210	55.000	55.000	Continuing	Continuing

A. Mission Description and Budget Item Justification

Computer, networking, and communication technologies have rapidly matured in the last decade and have had a profound effect on DoD weapons systems. In many instances the combination of those technologies has become either the integral piece of many of the emerging traditional land, air, and sea based weapon platforms or have become a stand alone, non-platform based virtual weapon system. In recognition of this fact, the Secure Information and Network Systems project will develop and test emerging computer, communications, and network systems where the impact of the systems and the vulnerabilities of the systems are not kinetically based. The project will develop, integrate, and test prototypes of promising network security technologies generated in projects such as, but not limited to, those developed in DARPA's Information & Communications Program Element (PE 0602303E) and Cognitive Computing Systems Program Element (PE 0602304E).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Rapid Software Development using Binary Components (RAPID) ***Description:*** The Rapid Software Development using Binary Components (RAPID) program will develop a system to identify and extract software components for reuse in new applications. The DoD has critical applications that must be ported to future operating systems. In many cases, the application source code is no longer available requiring these applications to continue to run on insecure and out-dated operating systems, impacting day-to-day operations. RAPID technologies will transition to the Services. ***FY 2011 Accomplishments:*** - Conceptualized an approach to technology refresh for critical defense software based on new approaches in binary executable program analysis, in particular by identifying and automatically extracting program functional components. - Identified multiple key legacy target applications. ***FY 2012 Plans:*** - Identify a baseline intermediary representative language specification for the RAPID system. - Design and prototype RAPID system architectures to enable functional identification and functional extraction. ***FY 2013 Plans:*** - Demonstrate the proof-of-concept system, showing identification, extraction and combination of components. - Complete an initial implementation of the user interface.	8.400	17.030	24.340
Title: Cyber Insider Threat (CINDER)	-	15.000	18.500

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**PROJECT** CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Cyber Insider Threat (CINDER) program will develop technologies for identifying advanced cyber threat missions that may be currently ongoing within DoD and government interest systems and networks. The program focuses on identifying ongoing adversary missions rather than a person, program, or particular piece of malware. Current cyber defenses are primarily based on network and host intrusion detection and look for break-ins and abnormal behavior without context. The CINDER program will build tools and techniques that apply mission templates of advanced cyber espionage onto seemingly normal internal system and network activity. Through this CINDER will uncover ongoing advanced persistent cyber threats and espionage within our cyber environments. Capabilities from this program will transition to DoD and/or the defense industrial base. ***FY 2012 Plans:*** - Identify constraints for each class/mission and demonstrate constraint detection methodologies. - Quantify probability of detection and probability of false alarm as a function of adversary class and mission for each system. - Design and build scalable prototype systems. ***FY 2013 Plans:*** - Evaluate adversary missions and observables on targeted systems. - Demonstrate cyber espionage detection capability on Government data sets. - Evaluate avoidance and obfuscation tactics against mission template detection.			
Accomplishments/Planned Programs Subtotals	8.400	32.030	42.840

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603760E: *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**PROJECT** CCC-CLS: *CLASSIFIED*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
CCC-CLS: *CLASSIFIED*	47.438	88.597	55.863	-	55.863	62.101	62.672	59.823	57.283	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Classified DARPA Program ***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2011 Accomplishments:*** Details will be provided under separate cover. ***FY 2012 Plans:*** Details will be provided under separate cover. ***FY 2013 Plans:*** Details will be provided under separate cover.	47.438	88.597	55.863
Accomplishments/Planned Programs Subtotals	47.438	88.597	55.863

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	79.824	107.226	3.000	-	3.000	-	-	-	-	Continuing	Continuing
CLP-01: *CLASSIFIED DARPA PROGRAMS*	79.824	107.226	3.000	-	3.000	-	-	-	-	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	167.008	107.226	107.483	-	107.483
Current President's Budget	79.824	107.226	3.000	-	3.000
Total Adjustments	-87.184	-	-104.483	-	-104.483
• Congressional General Reductions	-0.764	-			
• Congressional Directed Reductions	-16.700	-			
• Congressional Rescissions	-58.402	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-7.450	-			
• SBIR/STTR Transfer	-3.868	-			
• TotalOtherAdjustments	-	-	-104.483	-	-104.483

Change Summary Explanation

FY 2011: Decrease reflects reductions for the Section 8117 Economic Adjustment, poor justification material, rescissions, internal below threshold reprogrammings and the SBIR/STTR transfer.
FY 2013: Decrease reflects discontinuation of selected classified programs.

C. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Classified DARPA Programs ***Description:*** Classified DARPA Programs ***FY 2011 Accomplishments:***	79.824	107.226	3.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603765E: *CLASSIFIED DARPA PROGRAMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Details will be provided under separate cover. ***FY 2012 Plans:*** Details will be provided under separate cover. ***FY 2013 Plans:*** Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	79.824	107.226	3.000

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011**	**FY 2012**	**FY 2013 Base**	**FY 2013 OCO**	**FY 2013 Total**	**FY 2014**	**FY 2015**	**FY 2016**	**FY 2017**	**Cost To Complete**	**Total Cost**
Total Program Element	219.185	208.503	236.883	-	236.883	245.684	242.142	232.651	242.378	Continuing	Continuing
NET-01: *JOINT WARFARE SYSTEMS*	61.875	61.087	68.593	-	68.593	70.793	73.873	69.217	71.312	Continuing	Continuing
NET-02: *MARITIME SYSTEMS*	41.839	49.704	54.250	-	54.250	57.011	53.096	39.096	40.535	Continuing	Continuing
NET-CLS: *CLASSIFIED*	115.471	97.712	114.040	-	114.040	117.880	115.173	124.338	130.531	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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 2011**	**FY 2012**	**FY 2013 Base**	**FY 2013 OCO**	**FY 2013 Total**
Previous President's Budget	234.985	235.245	226.485	-	226.485
Current President's Budget	219.185	208.503	236.883	-	236.883
Total Adjustments	-15.800	-26.742	10.398	-	10.398
• Congressional General Reductions	-1.159	-			
• Congressional Directed Reductions	-7.000	-26.742			
• Congressional Rescissions	-3.973	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	5.500	-			
• Reprogrammings	-3.300	-			
• SBIR/STTR Transfer	-5.868	-			
• TotalOtherAdjustments	-	-	10.398	-	10.398

Change Summary Explanation

FY 2011: Decrease reflects reductions for the Section 8117 Economic Adjustment, unsustained growth, internal below threshold reprogrammings, rescissions and the SBIR/STTR transfer.

FY 2012: Decrease reflects reductions for unsustained growth and reduction to new starts.

FY 2013: Increase reflects minor repricing.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-01: *JOINT WARFARE SYSTEMS*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
NET-01: *JOINT WARFARE SYSTEMS*	61.875	61.087	68.593	-	68.593	70.793	73.873	69.217	71.312	Continuing	Continuing

A. Mission Description and Budget Item Justification

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: High Energy Liquid Laser Area Defense System (HELLADS)	15.175	25.130	40.962
Description: This program builds upon the past achievements of the High Energy Liquid Laser Area Defense System (HELLADS) development program and the Aero-Adaptive Aero-Optic Beam Control (ABC) program, budgeted in DARPA PE 0602702E, Project TT-06. The goal of the HELLADS program is to develop a high-energy laser weapon system that will provide an order of magnitude reduction in weight compared to existing laser systems. HELLADS will enable high-energy lasers (HELs) to be integrated onto tactical aircraft and will significantly increase engagement ranges compared to ground-based systems, in addition to enabling high precision/low collateral damage and rapid engagement of fleeting targets for both offensive and defensive missions. Advancements in beam control and other subsystems that are required for the practical integration of a laser weapon into existing tactical platforms will be explored. With the assistance of the Services, the HELLADS program will pursue the necessary analysis, coordination, and design activity for a prototype laser weapon system incorporating the HELLADS laser system and the ABC turret into air, ground, or sea-based tactical vehicles. ***FY 2011 Accomplishments:*** - Initiated investigation of alternative approaches to beam control and laser integration to enable reduced size, weight, and power (SWaP) as well as reduced platform performance impacts.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Conducted initial modeling and simulation for system performance and target interactions. ***FY 2012 Plans:*** - Initiate laser weapon system module preliminary design to integrate laser, beam control, power, thermal management, and battle management systems in a flight-qualifiable package. - Design suitable physical and functional platform interfaces for the modularized weapon system. - Coordinate other activities necessary for safe and effective operation of the prototype system on the test platform. ***FY 2013 Plans:*** - Complete critical design and initiate fabrication of laser weapon module's subsystems including integrating structure, platform interfaces, beam control, and battle management subsystems to facilitate early low power demonstration of tactical performance.			
Title: Legged Squad Support System (LS3) ***Description:*** The Legged Squad Support System (LS3) program will explore the development of a mission-relevant quadruped platform scaled to unburden the infantry squad and hence unburden the soldier. In current operations, soldiers carry upwards of 50lbs of equipment, in some cases over 100lbs, over long distances in terrain not always accessible by wheeled platforms that support infantry. As a result, the soldier's combat effectiveness can be compromised. The LS3 program will design and develop prototypes capable of carrying 400lbs of payload for 20 miles in 24 hours, negotiating terrain at endurance levels expected of typical squad maneuvers. LS3 will leverage technical breakthroughs of prior biologically inspired legged platform development efforts. It will develop system designs to 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. Anticipated service users include the Army, Marines, and Special Forces. ***FY 2011 Accomplishments:*** - Completed critical design review and prototype build plan. - Conducted final subsystem test stand development, testing, and analysis of results to support design estimates. - Completed initial integration of controls to demonstrate walk and trot. - Integrated and tested initial perception components in a preliminary perception head system. ***FY 2012 Plans:*** - Conduct walkout and acceptance testing of system. - Integrate perception and control techniques into the platform to facilitate the use of autonomy. - Conduct trades and select heavy fuel engine for system upgrade. ***FY 2013 Plans:*** - Complete build of prototype systems resulting in two standard systems and one that utilizes a heavy fueled engine option.	16.083	18.052	11.231

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-01: *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Perform experiments to assess the mobility and perception capabilities of the platform from a technology standpoint. - Complete technical and operational assessments with the U.S. Marine Corps to evaluate the abilities of the LS3 platform within mission objectives and applied to the LS3 mission profile.			
Title: Robotics Olympics* ***Description:*** *Formerly Robotic Activators and Physical Performance Improvements in Dynamic Environments (RAPPIDE) Advancements are being made in land-capable, high degree-of-freedom unmanned platforms to enable mobility over very complex terrain. Many current prototypes are inspired by biological systems and while proof-of-principle systems have or are demonstrating unprecedented mobility, limitations have emerged. Advanced capabilities in perception, control, and physical capability/coordination are needed to work autonomously in human environments. These are critical enablers for performing mission-relevant tasks in austere and remote regions, partially-destroyed roads, high-threat anti-access/area denied environments, rubble-filled areas, and providing greater range/endurance for soldiers, platforms, and personnel. The Robotics Olympics program will boost innovation in autonomous systems and expand platform utility through enhanced actuation, energy density, perception, locomotion, agile reconfiguration, and design efficiency. Program thrusts are centered on a progressive regimen of physical problem solving, real-time team oriented tasks, and dynamic adaptation designed to build "machine trust", especially when integrated with humans in a variety of operational environments. The Robotics Olympics program consists of a series of Olympic and military obstacle course style challenge events that will focus on technology solutions to demonstrate and test robot athleticism for human capabilities. Robotics Olympics events will drive advances in power systems, agility and speed, precision in perception tied to platform coordination, dexterity, and impulsive power. Program objectives focus on regenerative technologies to expand mobility and extend endurance of unmanned platforms, advanced tactile and manipulation capabilities, and tools for cost effective test, build, and validation of autonomous technology. The effort is also aimed at inspiring and promoting Science Technology and Mathematics (STEM) initiatives. Anticipated Service users include the Army, Marines, and Special Forces. ***FY 2012 Plans:*** - Develop online outreach support for the Robotics Olympics challenge. - Conduct DoD and industry baseline assessment. - Initiate development of specific challenge events, including methodology, metrics, and parameters. ***FY 2013 Plans:*** - Coordinate funded prizes and support for the Robotics Olympics Challenge.	-	5.885	8.200

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-01: *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Define Robotics Olympics event performance and test criteria.			
Title: Counter Laser Technologies ***Description:*** The goal of the Counter Laser Technologies program is to develop a suite of technologies to increase the survivability of United States weapons platforms when encountering a high energy laser attack. Laser countermeasures include systems and materials for detection and warning, material treatments to harden vulnerable surfaces, computer models to plan mission engagements to favor U.S. system survivability when under high energy laser attack, and techniques to degrade or destroy the offending laser weapon. The High Energy Laser (HEL) lethality of concern in this program is apart from on-going efforts within the Services for sensor or eye protection from laser illumination. Counter Laser Technologies addresses the HEL's ability to deposit energy on the weapon or platform to melt through, fracture, or weaken the body, thereby disabling or destroying it. This effort will initially focus on characterizing the vulnerability mechanisms of a candidate set of weapons and platforms, developing warning systems to rapidly determine the attributes of the inbound threat (vector of origin, wavelength, power, format), and developing material solutions (skin treatments, material hardening methods). Additional effort will focus on ways to proactively degrade or destroy offending laser performance by altering the laser's internal optics or by modifying the laser's line of sight to the target. Technologies from this program will transition to platform and weapon system developers in all Services. ***FY 2013 Plans:*** - Assess vulnerability mechanisms for a candidate set of U.S. weapons and platforms. - Initiate development of material treatments and sensor systems to enhance platform situational awareness of laser attack. - Initiate laser engagement modeling effort to advise development of material solutions and tactics to survive high energy laser attack.	-	-	4.100
Title: Battlefield Illusion ***Description:*** This program will develop methods and technologies to enable our forces to manage the adversary's sensory perception to confuse, delay, inhibit, or misdirect their actions in the highly dynamic, close-range, visual/acoustic-dominated environment. The current operational art of human-sensory battlefield deception is largely an ad-hoc practice; advancements in the understanding of how humans use their brains to process sensory inputs will inform the development of techniques and systems in the auditory and visual regimes to provide tactical advantage for our forces, and provide technology tools for incorporation into the design of battlefield systems. This interdisciplinary effort will develop methodologies based on human cognitive insights and investigations, and apply those methodologies to develop, integrate, demonstrate and assess the operational effectiveness of advanced human-deceptive technologies on military ground, sea, and airborne systems. Technologies from this program are anticipated to transition to the Services.	-	-	4.100

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2013 Plans: - Investigate novel technologies to apply to the audio and visual deception regimes, and assess their applicability to an operationally-relevant demonstration of value, both in the battlefield and as a design tool. - Develop and demonstrate the effectiveness of deceptive techniques and technologies against adversaries in the visual and auditory regimes; quantify the results in operationally relevant terms.			
Title: Network Targeting ***Description:*** The Network Targeting program will develop advanced capabilities for a specified emitter density, operating environment, radio frequency (RF) signal geo-location accuracy, probability of correct RF signal identification and probability of false alarm. Each phase will progressively mature the design and technologies required to achieve system performance goals and move incrementally toward an operational system. The technology is planned to transition to the Services in FY 2013. ***FY 2011 Accomplishments:*** - Demonstrated real-time processing on brassboard hardware. - Conducted performance validation via demonstrations in a complex operational environment. ***FY 2012 Plans:*** - Optimize and integrate algorithms with modified software radio platform. - Demonstrate networked real-time processing on a software radio platform.	12.310	7.220	-
Title: Chemical Analysis Sans Machinery (CASM) ***Description:*** The Chemical Analysis Sans Machinery (CASM) program will develop novel materials and fabrication methods to produce high throughput, autonomous, low cost, chemical analysis devices. This program will transition to the Services. ***FY 2011 Accomplishments:*** - Fabricated materials with more rapid response time for chemical analysis. - Fabricated materials that are more reliable and sensitive for chemical analysis. - Integrated novel materials and technologies into chemical analysis devices. ***FY 2012 Plans:*** - Test chemical analysis devices against representative levels of appropriate chemicals. - Improve manufacturing processes to demonstrate clear path to low cost production. - Improve durability and robustness of device for increased shelf-life.	7.551	4.800	-
Title: Geospatial Exploitation (GEO)	7.516	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-01: *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Geospatial Exploitation (GEO) thrust explored 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). GEO algorithm architectures were explored to achieve scalability through spatial, temporal and ontological partitioning. GEO technologies are planned for transition to the National Geospatial-Intelligence Agency (NGA). Activities funded within the GEO research space include: The Urban Reasoning and Geospatial Exploitation Technology (URGENT) program developed a 3-D urban object recognition and exploitation system that enabled advanced mission planning and situation analysis capabilities for the warfighter operating in urban environments. URGENT created techniques for the rapid exploitation of EO and LIDAR sensor data at the city scale to recognize urban objects down to the soldier scale. The Geospatial Representation Integrated Dataspace (GRID) program investigated an automated geospatial data fusion, modeling, and dissemination technology for the tactical warfighter. Geospatial registration algorithms have demonstrated success in automatically fusing geospatial data from multiple Intelligence, Surveillance and Reconnaissance (ISR) sources (e.g., electro-optical, full motion video, hyperspectral, and LIDAR) and encoding the fused data as a temporally indexed volumetric model that can potentially reduce geospatial theater ISR sensor data storage requirements while enhancing image quality for exploitation. ***FY 2011 Accomplishments:*** Urban Reasoning and Geospatial Exploitation Technology (URGENT) - Implemented a reasoning capability that exploits knowledge from Geographic Information System (GIS) documents. - Completed the process of transition of selected object recognition technology to a military geospatial analysis environment. Geospatial Representation Integrated Dataspace (GRID) - Defined framework for the GRID format standard. - Demonstrated the volumetric encoding of electro-optical data from tactical sensors.			
Title: Multipath Exploitation Radar (MER) ***Description:*** The Multipath Exploitation Radar (MER) program addressed radar deficiencies in urban operations: limited line of sight due to urban structures and excessive "confusers" due to multipath reflections. This program exploited multipath bounces to detect and track moving targets beyond non-line-of-sight (NLOS) and extended the area coverage rate of airborne sensors by a factor of six or more over physical line-of-sight limits. This capability has been transitioned to the Air Force and Army. ***FY 2011 Accomplishments:***	2.240	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-01: *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Determined upper bounds for track accuracy, persistence, and target density that can be achieved using NLOS returns. - Developed system concept for persistent wide-area surveillance over large metropolitan areas using multiple platforms. - Quantified the radar hardware and processing requirements to implement MER and identified potential transition platforms. - Validated urban clutter model and tracking algorithms on urban radar data set. - Transitioned Multipath Exploitation Radar system technology to the Services.			
Title: Seismic/Acoustic Vibration Imaging (SAVI) ***Description:*** The Seismic/Acoustic Vibration Imaging (SAVI) program developed the capability to locate both buried landmines and near-surface tunnels using active acoustic and seismic sources coupled with a multi-pixel laser vibrometer. The capabilities have transitioned to the U.S. Army for development and employment of operational systems. ***FY 2011 Accomplishments:*** - Demonstrated final scaled system for active acoustic landmine and active seismic tunnel detection with laser vibrometer. - Transitioned system to the U.S. Army to support extended field trials and performance characterization against varied terrain and target types.	1.000	-	-
Accomplishments/Planned Programs Subtotals	61.875	61.087	68.593

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-02: *MARITIME SYSTEMS*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
NET-02: *MARITIME SYSTEMS*	41.839	49.704	54.250	-	54.250	57.011	53.096	39.096	40.535	Continuing	Continuing

A. Mission Description and Budget Item Justification

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 Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Distributed Agile Submarine Hunting (DASH)	12.387	37.995	43.000
Description: The diesel-electric submarine is an asymmetric threat in terms of its cost and consequential growth in numbers relative to our legacy maritime platforms. In addition, these submarines have trended toward lower acoustic signature levels, and have grown in lethality. The Distributed Agile Submarine Hunting (DASH) program intends to reverse the asymmetric advantage of this threat through the development of advanced standoff sensing from unmanned systems. Deep ocean sonar nodes will operate at significant depths in open ocean areas to achieve large fields of view to detect submarines overhead. Each deep node is the maritime equivalent of a satellite, and is referred to as a subullite. The significant field of view, along with the advantage of low-noise phenomena at extreme depths will permit a scalable number of collaborative sensor platforms to detect and track submarines over large areas. For the vast shallow continental shelf areas, the program similarly adopts distributed mobile sensors, but instead leverages insights in non-acoustic sensing from above. The effort is highly focused on achieving new detection modalities with sufficient low power, weight, and size, to enable UAV implementations. Initial efforts will focus on identifying the best detection methods leveraged from state-of-the-art sensors and new physical and operational insights. From this work, prototype systems will evolve through at-sea testing and sensor integration. The program will achieve breakthrough technology for long-range detection and classification, communications, energy management, sensor and platform integration, and robust semiautonomous processing and control for distributed sensing platforms. This program will transition to the Navy.			
FY 2011 Accomplishments: - Initiated designs of multiple configurable sonar systems. - Initiated development of key deep ocean subsystems. - Conducted in-water measurements to assess the feasibility of advanced sensor and communication concepts. - Collected signature and environmental data needed to support technology designs. - Demonstrated feasibility of non-traditional active sonar concept on at-sea data and provided this concept to the Navy.			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-02: *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Initiated trade studies to investigate non-acoustic sensing approaches for UAV-based Antisubmarine Warfare (ASW) in shallow water. ***FY 2012 Plans:*** - Complete in-water feasibility measurements using key deep-ocean sensing subsystems. - Complete designs for distributed (multi-node) deep-ocean system prototypes. - Begin integration of deep-ocean sensing and communication subsystems for initial capability demonstration of a single node. - Conduct testing of single node prototypes (sensor/communications) in realistic ocean environments. - Demonstrate non-traditional active sonar concept on operationally relevant data and develop a transition plan with the Navy. - Complete non-acoustic sensor and system studies to guide development trajectories for UAV-based ASW. - Initiate non-acoustic sensor designs for UAV-based ASW. - Initiate on-going data collections for non-acoustic ASW effort. - Assess performance of candidate non-acoustic ASW sensors by analysis of collected data. ***FY 2013 Plans:*** - Integrate multiple sonar nodes into a system prototype scalable to relevant areas and duration for deep-ocean surveillance. - Initiate planning for the demonstration of a multi-node system prototype in a realistic environment. - Complete non-acoustic signature discovery and assessment. - Begin development of non-acoustic sensors tailored to discovered signatures. - Conduct trade analysis for UAV-based non-acoustic ASW system designs to produce preliminary system designs.			
Title: Unmanned/Minimally-manned Underwater Vehicle (UMUV) ***Description:*** Increasing requirements for missions in shallow littoral waters have created a need for a survivable and cost-effective capability to perform intelligence surveillance and reconnaissance, antisubmarine warfare, special operations forces, and other missions in the littorals. Today we risk manned submarines in waters that are shallower than the length of our hulls and we pit these high value assets against diesel electric submarines that in some cases pose an overmatching threat against our systems in these shallow waters. The Unmanned/Minimally-manned Underwater Vehicle (UMUV) program will develop a vehicle specifically designed to operate in the littoral battlespace with the capability of performing littoral missions that span a wide range of complexity and can be performed with a small manned crew or autonomously (i.e., unmanned) depending upon mission requirements. The UMUV will have the autonomy, range and endurance to drive to the fight from a safe basing location, will be capable of carrying the full range of payloads that are needed to support operational needs in littoral waters, and will provide the capability to perform missions where risk to personnel limits our willingness to execute these missions. The program will explore low-cost derivatives of commercial underwater vehicles, the integration of advanced communication and sensor technologies, and the teaming of the UMUV with manned systems. The UMUV program will transition to the Navy.	-	5.500	3.250

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
FY 2012 Plans: - Perform technology trades to assess key vehicle capabilities. - Develop concept of operations. ***FY 2013 Plans:*** - Explore the conceptual design of alternative approaches to the UMUV system.			
Title: Structural Logic ***Description:*** The Structural Logic program is developing platform structures and frames that can adapt to varying loads and simultaneously exhibit both high stiffness and high damping. This program will demonstrate the utility of negative stiffness structural elements developed under the Multifunctional Materials and Structures program, budgeted in PE 0602715E, Project MBT-01, in the ridged support frames of real world DoD platforms. As the demands on military platforms increase, so does the need for structures to mitigate the shock and vibrations applied by dynamic environments. Today's structures exhibit limited adaptability and typically achieve either extreme stiffness or damping. In military platforms, extremely stiff structures provide high strength, but readily transfer loads to passengers often resulting in serious injury. Conversely, existing damping structures can reduce the load transferred to passengers, but only at the expense of structural strength and integrity. By demonstrating the ability to combine stiffness, damping, and dynamic range in a single structure, the Structural Logic program will enable the design of military platforms with the ability to continually adapt their properties to match the demands of a dynamic environment. The program will transition to the Services. ***FY 2013 Plans:*** - Initiate the design of a ridged support frame for a platform structure that incorporates arrays of adaptive structural sub-assemblies made up of mechanical programs of tiered negative stiffness structural elements. - Perform final demonstration of the technology in a realistic system.	-	-	8.000
Title: Blue Laser for Submarine Laser Communications (SLC) ***Description:*** The Blue Laser for Submarine Laser Communications (SLC) program will develop the critical laser technology necessary to support the requirements for Non-Acoustic Anti-Submarine Warfare (NAASW), mine detection, and SLC. This program will develop the world's first wall-plug efficient laser that operates at an optimal water transmission band of open ocean water and at the wavelength of a Cesium Atomic Line Filter, which will enable duplex communications for the submarine at speeds and depths. Technology developed under SLC will be transitioned to the Navy. ***FY 2011 Accomplishments:*** - Initiated developments of the laser brassboard modules and Cesium Atomic Line Filter receivers.	18.486	6.209	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	R-1 ITEM NOMENCLATURE PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	PROJECT NET-02: *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Tested airborne and submarine-based brassboard transmitters for wavelength, energy per pulse, repetition rate, and beam quality. - Integrated the second gimbal and laser anamorphic zoom; tested with the receiver subsystem in the lab. - Developed the data recording and field calibration systems and the Low Probability of Intercept (LPI) receiver. - Completed demonstration of High Pulse Repetition Rate Blue Laser for Non-Acoustic Anti-Submarine Warfare laser identification detection and ranging applications. - Developed and pressure tested the submarine transmitter canisters, tested receiver canisters and developed fairings and electrical cabling. - Developed the aircraft installation, fabrications, and installed aircraft modifications. - Conducted test planning and laser safety planning and reviews. ***FY 2012 Plans:*** - Transition adaptive data rate controllers and Cesium Atomic Line Filter to Navy.			
Title: Thermal Management System for Ship Decks (TMD) ***Description:*** It is anticipated that the high engine exhaust temperatures from the next generation of Vertical Take Off and Landing (VTOL) aircraft deployed on Navy ships will dramatically reduce the life of both the deck structure and the non-skid surfaces. The Thermal Management System for Ship Decks (TMD) addressed this problem by demonstrating a heat distribution system with an integrated thermally-stable non-skid coating. The TMD transitioned to the Navy for integration into amphibious assault ships. ***FY 2011 Accomplishments:*** - Conducted assessment of thermo physical properties of non-skid coatings and developed thermally resistant non-skid coating. - Completed development, construction, and evaluation of a small-scale, non-skid, coated, passively cooled thermal management system.	4.000	-	-
Title: Tango Bravo ***Description:*** Based on the results of the DARPA/Navy Submarine Design Study, the Tango Bravo technology evaluation program explored design options for a reduced-size submarine with equivalent capability of the VIRGINIA Class submarine. The implicit goal of this program was to reduce platform infrastructure and, ultimately, the cost of future design and production of submarines. Elements of the Tango Bravo program transitioned to the Navy. ***FY 2011 Accomplishments:*** - Completed Shaftless Propulsion integrated system testing (in-air, full load motor testing). - Completed Shaftless Propulsion in-water acoustic and endurance testing.	1.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-02: *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Completed Shaftless Propulsion demonstrator test results analysis and modeling validation/updates.			
Title: Persistent Ocean Surveillance (POS) ***Description:*** The Persistent Ocean Surveillance (POS) program combined geolocation techniques, such as global positioning systems, with station keeping and intra-sensor communication technologies to provide long-term ocean environment sensing buoys. A range of technologies were considered, including those that rely on the local environment (i.e., wind, ocean waves, solar energy, temperature differentials) for their power; miniature geolocation technologies; and technologies for sensor data storage, transmission, and intra-field communications. The Renewable At-Sea Power program focused on efficient energy capture from the environment in order to achieve capability for fully renewable power at sea. Technology from this program has been made available for transition to the Navy. ***FY 2011 Accomplishments:*** - Completed design, fabrication, and assembly of instrumented prototype platform. - Integrated power take-off device with instrumented prototype platform. - Conducted at-sea testing of instrumented platform. - Performed modeling and analyses of near-surface vehicle docking concepts.	1.500	-	-
Title: River Eye ***Description:*** The River Eye effort provided a new capability to predict or assess, in real time, river and estuary conditions that enable special operations mission planning and execution. New techniques were developed to indirectly determine current speed and direction by remotely sensing advection of scene features. Estimated bathymetry data was obtained from this current data and advanced inverse-circulation modeling. Forward circulation models used the bathymetry data to predict future currents and water heights in a mission planning decision support tool. An initial set of algorithms and processes transitioned to the Navy and National Geospatial-Intelligence Agency in FY 2010; in FY 2011, the algorithms were extended to enable night-time capability, and water depth retrieval algorithms were investigated. ***FY 2011 Accomplishments:*** - Developed current and bathymetry algorithms for use with infrared (IR) image data, leading to a day/night capability. - Collected IR data on rivers and estuaries for testing and evaluation of the algorithms. - Developed IR sensor payload prototype for a small tactical unmanned air vehicle (TUAV).	4.466	-	-
Accomplishments/Planned Programs Subtotals	41.839	49.704	54.250

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-02: *MARITIME SYSTEMS*

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, **RDT&E Project Justification:** PB 2013 Defense Advanced Research Projects Agency		**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603766E: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**PROJECT** NET-CLS: *CLASSIFIED*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
NET-CLS: *CLASSIFIED*	115.471	97.712	114.040	-	114.040	117.880	115.173	124.338	130.531	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Classified DARPA Program ***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2011 Accomplishments:*** Details will be provided under separate cover. ***FY 2012 Plans:*** Details will be provided under separate cover. ***FY 2013 Plans:*** Details will be provided under separate cover.	115.471	97.712	114.040
Accomplishments/Planned Programs Subtotals	115.471	97.712	114.040

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	257.780	271.802	299.438	-	299.438	273.605	276.322	275.481	295.392	Continuing	Continuing
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	29.450	38.868	54.415	-	54.415	47.364	47.965	47.965	47.404	Continuing	Continuing
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	109.476	85.495	96.317	-	96.317	94.445	94.971	93.971	108.986	Continuing	Continuing
SEN-03: *EXPLOITATION SYSTEMS*	62.995	83.999	65.619	-	65.619	55.199	57.013	57.013	60.013	Continuing	Continuing
SEN-CLS: *CLASSIFIED*	55.859	63.440	83.087	-	83.087	76.597	76.373	76.532	78.989	Continuing	Continuing

A. Mission Description and Budget Item Justification

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.

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.

The Sensors and Processing Systems project develops and demonstrates the advanced sensor processing technologies and systems necessary for the intelligence surveillance and reconnaissance (ISR) mission. The project is primarily driven by four needs: 1) providing day-night ISR capabilities against the entire range of potential targets; 2) countering camouflage, concealment and deception of mobile ground targets; 3) detecting and identifying objects of interest/targets across wide geographic areas in near real-time; and 4) enabling reliable identification, precision fire control, tracking, timely engagement and accurate battle damage assessment of ground targets.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
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 2011**	**FY 2012**	**FY 2013 Base**	**FY 2013 OCO**	**FY 2013 Total**
Previous President's Budget	205.032	271.802	237.238	-	237.238
Current President's Budget	257.780	271.802	299.438	-	299.438
Total Adjustments	52.748	-	62.200	-	62.200
• Congressional General Reductions	-1.042	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-10.098	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	64.500	-			
• Reprogrammings	5.700	-			
• SBIR/STTR Transfer	-6.312	-			
• TotalOtherAdjustments	-	-	62.200	-	62.200

Change Summary Explanation

FY 2011: Increase reflects internal below threshold reprogrammings and transfers from Army JIEDDO in support of Wide Area Surveillance technology offset by reductions for the Section 8117 Economic Adjustment, rescissons and the SBIR/STTR transfer.
FY 2013: Increase reflects additional emphasis on imaging and surveillance technology and classified programs.

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603767E: *SENSOR TECHNOLOGY*	**PROJECT** SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	29.450	38.868	54.415	-	54.415	47.364	47.965	47.965	47.404	Continuing	Continuing

A. Mission Description and Budget Item Justification

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 Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Adaptable Navigation Systems (ANS) ***Description:*** The Adaptable Navigation Systems (ANS) program will provide the U.S. warfighter with the ability to navigate effectively in all environments, including when Global Positioning System (GPS) is unavailable due to hostile action (jamming) or blockage by structures and foliage. The ANS approach relies on two major technology innovations. The first is the use of Signals of Opportunity (SoOp) from a variety of ground, air, and space-based sources. These will be received on the Services' forthcoming software-defined radios and use specially tailored algorithms to determine position. The second technology innovation allows SoOp-based position information to be combined with inertial and other sensors to enable flexible navigation systems that can be reconfigured in the field to support any platform or environment. While component technology for positioning, navigation, and timing is advancing rapidly (in the form of Micro Electro-Mechanical System devices, clocks, and new aiding sensors), real-time integration and reconfiguration of these components is not possible given today's navigation filters and centralized processing architectures, which are inherently fragile to change. Recent advances in mathematics, data abstraction, and network architectures could enable "plug-and-play" integration of both existing and future navigation components to allow real-time integration and reconfiguration of navigation systems. If successful, major improvements in navigation accuracy and system cost could also be realized. Early transition partners would include all Services, with emphasis on platforms and users that must operate in multiple environments. ***FY 2011 Accomplishments:*** - Developed non-form-fit prototype ANS system. - Demonstrated ANS prototype system in urban canyons and inside buildings.	14.497	14.471	16.802

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Conducted field tests and demonstrated the functional ANS prototype in user-selected environments such as forested, jungle and open environments, and for airborne platforms. - Validated performance prediction models from previous phases for use in mission planning tools. - Identified candidate filter, sensor, and architecture designs to enable plug-and-play all environment precision navigation and timing. - Quantified the required performance including accuracy and reconfiguration robustness to enable plug-and-play all environment precision navigation and timing. ***FY 2012 Plans:*** - Evaluate candidate filter, sensor, and architecture design for plug-and-play system. - Conduct tests to compare plug-and-play navigation system performance with existing state-of-the-art. - Develop system specification for platform-specific form factor of ANS reference stations. - Demonstrate SoOp-based ranging and navigation. - Develop and demonstrate through-the-earth communications for navigation (surface-to-subsurface communications). - Test and evaluate first generation 6-degree-of-freedom cold atom-based inertial measurement unit (IMU) in laboratory. - Design second generation cold atom-based IMU to meet platform-specified size, weight and power goals and begin planning for in-flight and/or at-sea testing. ***FY 2013 Plans:*** - Develop and test candidate filter, sensor, and architecture design for plug-and-play system. - Develop ANS reference stations to user-selected platform-specific form factors. - Demonstrate integration of SoOp-based ranging and navigation into ANS systems. - Test and evaluate ANS systems in sea, air, and land-based platforms in GPS-denied mission scenarios. - Test and evaluate second generation 6-degree-of-freedom cold atom-based IMU in flight and/or at sea.			
Title: Adaptable, Low Cost Sensors ***Description:*** The objective of the Adaptable, Low Cost Sensor program is to leverage commercial technology and commercial manufacturing techniques to improve the development time and significantly reduce the cost of sensors and sensor systems. Military sensors are currently developed as unique designs that fully integrate mission specific hardware required for sensing, with all of the other non-mission specific capabilities, including sensors (GPS), processing, memory storage and communications into a single device. Not only does this approach significantly increase the cost of the device, it makes changing requirements and the upgrading of any specific component extremely difficult. Nevertheless, significant advances have been made in the capabilities of commercial equipment for almost all of those capabilities, mostly driven by the smart phone industry. This makes it possible to create a mission-independent, designed-to-cost "commercial smart core" that can be combined with an appliqué of mission-specific hardware to provide the overall sensing capability. Because the core can be upgraded independently of	-	20.697	22.013

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
any particular sensor, sensors can make use of the advances and decreasing cost that is inherent in commercial technology. Because commercial technology can be used in the core, commercial development and manufacturing techniques can also be leveraged, further improving the cost and development time of sensor systems. In addition, this program will enable effective distributed sensor systems that were previously infeasible due to high cost of individual sensors. This program will transition to the Services. ***FY 2012 Plans:*** - Manufacture initial version of commercial smart core. - Identify candidate sensors for ground and airborne demonstrations and quantify the required performance, including adaptability. - Define objectives for distributed sensor systems (ground and UAV) and quantify performance against traditional, non-distributed systems. - Develop a distributed ground sensor system using smart core. - Develop smart core re-usable software and ground mission software. - Define objectives for ground system field test and plan field test activities. ***FY 2013 Plans:*** - Manufacture second version of commercial smart core. - Develop a cooperative sensor systems using smart core. - Refine smart core re-usable software and ground mission software. - Conduct field test of prototype sensor.			
Title: Visibuilding ***Description:*** The Visibuilding program developed technologies and systems for new building surveillance capabilities to detect personnel within buildings, determine building layouts, and locate weapons caches within buildings. This program developed techniques to inject and recover probing radar waveforms and unravel the complicated multipath in the return signals to enable the mapping and characterization of building interiors. Radar signals were used to image static structures directly. Doppler processing of radar signals was also being exploited to find, identify, and perform feature-aided tracking of moving personnel within a building and allow mapping of building pathways and stairways by monitoring traffic through buildings. Multipath and propagation effects were modeled and iteratively compared with hypotheses of building structures to provide 3-D building maps and large concentrations of metal materials like weapons. Technologies developed under this program will be made available to the Army and U.S. SOCOM for transition. ***FY 2011 Accomplishments:***	5.345	3.700	-

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Completed demonstrations of low-latency, radar-based prototype system and quantified ability to determine building layout and track insurgents within furnished multi-story buildings. - Identified viable alternative sensing modalities for continued development. ***FY 2012 Plans:*** - Transition the radar-based prototype to Army and U.S. SOCOM.			
Title: Multi-Function Optical Sensor ***Description:*** The expanded use of passive electro-optic (EO) sensors for detection and tracking (Infrared Search & Track Systems and Forward Looking Infrared Radar Systems) has increased the threat to our airborne systems. These sensors negate the advantages of our radars and radio frequency (RF)-based countermeasures such as digital radio frequency memory (DRFM). When used in the presence of DRFM and other RF countermeasures by our adversaries, EO sensors could provide overmatching defensive capabilities. The Multi-Function Optical Sensing program will provide an alternative approach to detecting, tracking, and performing non-cooperative target identification, as well as providing fire control for fighter class and long-range strike aircraft. This approach leverages emerging high-sensitivity focal plane array (FPA) and compact, multiband laser systems technology in the near/mid/long-wave infrared bands to develop a multi-function optical system. Technical challenges include the demonstration of inexpensive, multiband, large-format, photon-counting, high-bandwidth receivers and their integration into a multi-optical sensor suite compatible with airborne assets. The Multi-Function Optical Sensor program will result in an airborne system that can detect, geolocate, and identify targets at standoff ranges. Technologies from this program will transition into the Services. ***FY 2013 Plans:*** - Initiate development of multiband, high-speed active focal plane arrays. - Develop preliminary system architecture for airborne multi-function optical sensors. - Initiate development of new algorithms and signal processing approaches for effective use of multi-function optical sensing in offense and defensive applications.	-	-	8.500
Title: Electro-Optical Warfare ***Description:*** The proliferation of optical communications and sensor systems has created a need for electronic warfare (EW) approaches that can be used in the electro-optical (EO) domain. Unfortunately, while there is a sophisticated suite of counter RF approaches, there is no such capability against EO signals, which are hard to find; and when found, even harder to suppress. The EO Warfare program will extend EW into the optical domain by developing the capacity to defeat EO systems including: laser communications systems, EO/IR sensors, and laser imagers and seekers. This program will exploit the significant advances that have been made in compact lasers, laser spectrum agility, and microelectronics to develop optical EW systems including an optical digital radio frequency memory (DRFM) equivalent. Key challenges include detection and processing of optical signals for sensors (photon gating, embedded signal processing) integrated with detector arrays, and adaptive and computational optics that	-	-	3.550

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
can be applied to finding EO-based communications and active sensors. The product of the EO Warfare program is to develop new techniques and systems that can defeat laser communications and active optical sensor systems at >50km range. Improved understanding of countermeasures to active sensors will also improve the robustness of our own developmental and fielded Intelligence, Surveillance and Reconnaissance (ISR) and communications systems. Technologies from this program will transition to the Services. ***FY 2013 Plans:*** - Identify the capabilities and shortfalls of detector arrays and compact lasers for detecting and suppressing EO threats. - Initiate, based on identified shortfalls, the development of advanced detector arrays and improvements to compact lasers. - Initiate the development of novel signal processing techniques that take advantage of advances in adaptive and computational optics and embedded processing initiatives. - Investigate the use of high-powered EO techniques to saturate or degrade optical receiver performance.			
Title: Multi-Modal Tunnel Detection ***Description:*** In today's asymmetric warfare, adversaries' persistent and expanded use of underground tunnels for tactical advantage is largely unchallenged. Underground and subterranean tunnels are being increasingly employed to hide a variety of tactical and strategic functions, including command and control, missile and artillery protection, lines of communication and staging area for military operations. Today's tunnel detection systems are based on single mode commercial sensor technology (Ground Penetrating Radar, seismic, resistivity, gravity, cone penetrator, and electromagnetic gradiometer). Despite significant technical efforts, these approaches still fail to identify tunnels in the presence of variable geology and urban complexity and clutter. Moreover, there is currently no technical basis for combining these modes into a more powerful detection schema. The Multi-Modal Tunnel Detection program will overcome these limitations by going back to basics to exploit the underlying physics of a tunnel's response to a variety of energy sources (acoustic, seismic, electromagnetic, chemical, resistivity, conductivity, lidar, multi/hyperspectral, and gravity/gravity gradient). This multi-sensor approach will be used in conjunction with advanced mathematics, new algorithms and processing techniques to develop and demonstrate approaches that optimally combine sensor modalities to characterize tunnels and reject clutter. Upon completion the Multi-Modal Tunnel Detection program will deny the use of underground facilities that currently thwart our existing ISR systems. This capability is expected to transition to the U.S. Army, U.S. Marine Corps, and U.S. Special Operations Command upon completion of a system demonstration phase. ***FY 2013 Plans:*** - Begin investigation of the fundamental interactions of various sensor modalities and geological structures indicative of tunnels and underground facilities. - Begin exploration of algorithms to combine sensor information.	-	-	3.550
Title: Low-Altitude Airborne Sensor System (LAASS)	2.065	-	-

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: The Low-Altitude Airborne Sensor System (LAASS) program developed airborne sensing capabilities to find and characterize underground facilities (UGFs) used to shield and protect strategic and tactical activities. This includes command and control, weapons storage, 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 significantly increased our ability to seek out underground facilities and map out their vulnerabilities and backbone structure. LAASS technologies have been made available to Northern Command, Southern Command, Strategic Command, and Defense Threat Reduction Agency for transition. ***FY 2011 Accomplishments:*** - Identified, through modeling and laboratory tests, the critical development risks for the concept system design, component gravity gradiometry sensor technologies, and supporting subsystems. - Documented expected performance of system concept (sensor, installation, processing, CONOPS). - Conducted multi-modal fusion study to validate clutter rejection and tunnel detection improvement.			
Title: Rescue Transponder (RT) ***Description:*** Building upon technologies developed in other sensor programs, the Rescue Transponder (RT) program investigated the use of a unique localization and tracking technology to provide a very low probability of detection (LPD) call for help signal. The system used a wideband radio frequency signal with low power and extremely low duty cycle. The program developed a small, rugged transponder that provides a call for help to friendly forces. The RT system operates over ranges that enable rescue forces or surveillance systems to receive its signals. It supports accurate localization by rescue forces, and permits transmission of identifying, authenticating, and status information. The RT technology is transitioning to the Marine Corps. ***FY 2011 Accomplishments:*** - Completed development and delivered miniaturized receivers and extended-life tags to Marine Corps. - Completed transition to Marine Corps.	1.000	-	-
Title: Sferic-Based Underground Geo-positioning (S-BUG) ***Description:*** The Lightning Based (Sferic) Underground Geo-positioning (S-BUG) program addressed 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 could also detect the sferics, and real time or post-mission correlation with the surface data will enable geo-location of the subsurface receiver. Exploitation of naturally-occurring,	6.543	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
nondeniable signals has the potential to significantly reduce logistical requirements and increase operational standoff by orders of magnitude (1000+ km). Technologies have been made available to transition to the U.S. SOCOM and the Army. ***FY 2011 Accomplishments:*** - Completed design of prototype hardware for subsurface receivers and processors and through-the-earth communications. - Built and tested prototype hardware (receiver and processors) for sferic-based geopositioning and navigation. - Demonstrated above ground to below ground geopositioning.			
Accomplishments/Planned Programs Subtotals	29.450	38.868	54.415

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	109.476	85.495	96.317	-	96.317	94.445	94.971	93.971	108.986	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Behavioral Learning for Adaptive Electronic Warfare (BLADE) ***Description:*** The Behavioral Learning for Adaptive Electronic Warfare (BLADE) program will develop the capability to jam adaptive and rapidly evolving radio frequency (RF) threats in tactical environments and at tactically-relevant timescales. This will change the paradigm for responding to evolving threats from lab-based manual development to an adaptive in-the-field systems approach. When an unknown or advanced RF threat appears, BLADE networked nodes will dynamically characterize the emitter, synthesize an effective countering technique, and evaluate jamming effectiveness by iteratively probing, learning, and adapting to the threat. An optimization process will tailor near-real-time responses to specific threats, producing a countermeasure waveform that maximizes jam effectiveness while minimizing the required jamming resources. Thus BLADE will enable the rapid defeat of new RF threats and provide the warfighter with real-time feedback on jam effectiveness. The program is planned for transition to the Services. ***FY 2011 Accomplishments:*** - Developed and evaluated techniques for the detection and characterization of known and unknown communications threats using adaptive threshold detection and open-set signal classification. - Created techniques for jam waveform generation via learning and active probing techniques.	14.000	19.700	16.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Developed approaches for battle damage assessment to determine jam effectiveness through observation of changes in communications threat behavior. ***FY 2012 Plans:*** - Conduct non-real time testing in a laboratory environment demonstrating detection and characterization of known and unknown signals with sufficient fidelity to validate the program concept. - In non-real time, demonstrate the successful optimization of jamming waveforms using active probing and learning techniques. - Conduct non-real time battle damage assessment performance validation via laboratory testing. - Begin end-to-end system development for real-time open-air breadboard demonstrations. - Develop and evaluate techniques for the detection and characterization of known and unknown radar threats. ***FY 2013 Plans:*** - Optimize BLADE algorithms for real-time over-the-air operations and port to suitable breadboard computing platforms. - Perform construction, integration and testing of real-time hardware implementation. - Develop Red Team over-the-air testing methodology and perform system evaluations. - Enhance and refine BLADE transition plan in concert with relevant programs of record and Service partners. - Demonstrate initial adaptive radar countermeasure techniques.			
Title: Military Imaging and Surveillance Technology (MIST) ***Description:*** The Military Imaging and Surveillance Technology (MIST) program will develop a fundamentally new optical ISR capability that can provide high-resolution 3-D images to locate and identify a target at much longer ranges than is possible with existing optical systems. Several prototype optical surveillance and observation systems will be developed that will: (1) demonstrate probabilities of recognition and identification at distances sufficient to allow stand-off engagement; (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. The program will develop and integrate the necessary component technologies including high-energy pulsed lasers, receiver telescopes that have a field of view and depth of field that obviates the need for steering or focusing the optical system, computational imaging algorithms to improve system resolution, and data exploitation and analysis tools. Advances in laser systems, digital imagers, and novel image processing algorithms will be leveraged to reduce the overall size, weight and power of imaging systems to allow for soldier portable and UAV platform integration. MIST will also continue to integrate technologies developed under the Crosswind Sensor System for Snipers (C-WINS) and the Dynamic Image Gunsight Optics (DInGO) efforts. MIST will develop an optical rifle scope that enables a soldier, with minimal training, to shoot a firearm with marksman accuracy at range while also enhancing the capability for close quarters combat. The	11.993	31.645	40.955

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

MIST program will transition the developed rifle-scope to the Army, Marines, and Special Operations Forces. The optical ISR technology will transition to the Air Force and SOCOM.

FY 2011 Accomplishments:
- Completed design of the DInGO rifle-scope that will allow for retrofit upgrade as well as stand-alone application.
- Conducted laboratory demonstration of a high-energy pulsed fiber laser subsystem that is phase-locked to an external reference.
- Demonstrated a high-energy pulsed fiber laser with output power that can be scaled well above fundamental limitations of existing fiber laser systems.
- Completed the Preliminary Design Review level design for the MIST 3-D short-range imaging system based on advanced computation imaging techniques.
- Completed laboratory demonstration of the MIST 3-D short-range imaging system to assess the performance of computational imaging in high-resolution ISR sensors.
- Commenced development of a quarter-scale MIST 3-D imaging demonstrator prototype.
- Demonstrated the ability to increase the resolution of the MIST imaging technology by coherently phasing multiple independent apertures.
- Demonstrated that the MIST short-range receiver design provides a 25x increase in depth-of-focus and field -of-view compared to existing systems.
- Completed real-time hardware implementation of advanced image processing algorithms and system integration.

FY 2012 Plans:
- Complete development of a high-power pulsed fiber laser system with a size, weight, and power that is suitable for integration on a small or persistent airborne platform.
- Complete development of the DInGO rifle-scope prototype that provides a 1-10x image magnification as well as advanced computation algorithms to assist with target tracking, image enhancement, and image stabilization.
- Complete field testing of the prototype DInGO scopes in conjunction with the transition partner.
- Complete a Critical Design Review level design for the MIST short-range 3-D imaging system.
- Complete a brassboard demonstration of MIST short-range imaging designs that incorporates computational imaging and 3-D digital holographic imaging techniques to achieve the short range performance metrics.
- Complete development of two quarter-scale MIST 3-D imaging demonstrator prototypes.
- Begin integrating the high peak-power pulsed laser technology to increase the operating distance of the MIST 3-D imaging effort.
- Begin development of the MIST short-range 3-D imaging prototype for surveillance and identification applications.
- Begin to develop designs to extend the MIST operating range for aerial platforms.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Port algorithms from a Colfax processor to a mini processor board that is camera independent. - Begin development of rifle mount crosswind sensor system. - Evaluate rifle mounted crosswind sensor technologies. ***FY 2013 Plans:*** - Transition the quarter-scale MIST designs and prototypes. - Complete development of MIST short-range 3-D imaging prototypes. - Complete a Critical Design Review level design of the MIST 3-D long-range imaging system for operation on aerial platforms. - Demonstrate key technologies to enable operation at increased ranges. - Demonstrate rifle mounted crosswind sensor system. - Transition the rifle mounted crosswind sensor system to the Marine Corps.			
Title: Multifunction RF ***Description:*** The Multifunction RF program initially developed a helicopter pilot performance enhancement system for landing in degraded visual environments (DVE) such as dust clouds. Beyond landing aids in DVE, RF-based sensors can also be used for additional situational awareness, such as near ground obstacle avoidance, air-to-air collision avoidance, targeting/fire control, as well as many other combat support activities. Building on advancements made with RF sensors under this program, the program will further seek to eliminate many redundant RF elements of current independently-developed systems for landing in DVEs, terrain avoidance, obstacle avoidance, and targeting/fire control. This will reduce the overall weight, power usage, cost, and profusion of exterior antennas on military aircraft, thus enabling greater mission capability with reduced vehicle system integration burden. Transition is planned to the Services. ***FY 2011 Accomplishments:*** - Began system analysis of extreme high frequency multifunction radar. - Initiated design and development of advanced silicon tiles for electronically scanned antenna. ***FY 2012 Plans:*** - Initiate hardware design and development of multifunction RF system for advanced DVE sensor and lethality functions. - Complete initial demonstration of advanced silicon tile for electronically scanned antenna for multifunction RF sensor. - Define universal synthetic vision interface and demonstrate synthetic vision system in laboratory tests. ***FY 2013 Plans:*** - Complete laboratory testing of advanced DVE sensor suitable for flight testing. - Complete development and laboratory testing of key subsystem technologies for multifunction RF waveforms and arrays.	2.500	15.800	26.862

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Flight test synthetic vision system with Government Furnished Equipment sensor on Blackhawk platform.			
Title: Advanced Airborne Optical Sensing ***Description:*** The Advanced Airborne Optical Sensing program is developing electro-optical and infrared sensors and processing technologies for aerial platforms. Significant challenges have arisen as the result of two warfighting trends. First, the ever-changing mix of airborne platforms now includes a greater number of smaller UAVs. Second, the target set is increasingly challenging and now includes vehicles and individual dismounts that operate under foliage and in urban canyons, using camouflage, obscurants, and other means of concealment. In response to these challenges, the Advanced Airborne Optical Sensing program has developed enhanced optical, electro-optical, photonic and other technologies for airborne optical sensing systems. Specific examples of these technologies include: embedded image processors tailored to real-time detection, identification, and tracking of military targets; advanced laser radar technologies; hyper-spectral sensing technologies; flash detection and underwater object detection; advanced digital signal processing to support onboard image reconstruction, atmospheric correction, and system calibration; and adaptive optics techniques, such as deformable mirrors and liquid crystal spatial light modulators. The program has extended these technologies and is making them practical for airborne surveillance systems. Efforts in this program include: - The Standoff Precision ID in 3-D (SPI 3-D) program developed an affordable sensor package capable of high-resolution 3-D imaging for confirmatory target ID at long ranges, as well as full field of view (FOV) ranging to support precise geolocation of targets. The program included a series of ground-based and airborne demonstrations of SPI 3-D capabilities including: (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. The program will also produce high speed, ultra-sensitive photo detectors for systems requiring operation at very low photon counts. This supports long-range sensors that can detect highly obscured targets under canopy/camouflage as well as very wide-area searches for submerged targets, including sea mines and semi-submerged mobile vessels. - The HALOE (High Altitude Lidar Operations Experiment) program has demonstrated, in an operational environment, the full capability of a 3-D imaging system. The HALOE system provides support for current and emerging warfighter needs by delivering high-resolution, wide-area 3-D lidar imagery data in the OCONUS environment. This system provides the unprecedented capability to collect accurate, high resolution 3-D data over wide areas to support a wide range of high-value applications, including detailed mission planning, vertical obstruction detection, helicopter landing zone analysis, and imagery geolocation. The pathway to accomplish this goal includes improving the robustness and reliability of the sensor, conducting demonstrations, and training with CONUS flight tests leading to OCONUS operational experimentation in partnership with the Army.	12.618	7.700	6.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
HALOE successfully completed the CONUS flight testing phase and was deployed OCONUS for further testing and system checkout to address current and emerging needs of U.S. forces under the direction of commanders in theater during 2011. The completed HALOE system will transition to the U.S. Army. - The Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND) program developed a system for collecting and processing IR data operating as a framing sensor. The system accepts 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 decrease the time required to focus the sensor operator's attention on relevant targets. The TAILWIND system is planned for transition to the U.S. Army. ***FY 2011 Accomplishments:*** Standoff Precision ID in 3-D (SPI 3-D) - Completed integration of miniaturized components into the demonstration system. - Conducted ground and airborne demonstrations of the metric sensing and 3-D imaging on a manned aircraft, supporting transition to U.S. Air Force. - Designed and implemented target detection, identification, and tracking algorithms in high-performance signal processing hardware architectures. - Developed promising technologies identified for use for air platform to air target identification and location. High Altitude Lidar Operations Experiment (HALOE) - Deployed OCONUS and conducted test demonstrations. - Transitioned HALOE system to the Army in 2011. - Explored possible designs and development of compact configurations of HALOE that could be integrated with military unmanned and manned platforms. Tactical Aircraft to Increase Long Wave Infrared Nighttime Detection (TAILWIND) - Completed final design of infrared and color sensor package. ***FY 2012 Plans:*** High Altitude Lidar Operations Experiment (HALOE) - Explore additional applications for the high performance LIDAR components embedded within the HALOE system to optimize size, weight, and power for alternate platforms. ***FY 2013 Plans:*** High Altitude Lidar Operations Experiment (HALOE)			

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Develop additional applications for the high performance LIDAR components embedded within the HALOE system to optimize size, weight, and power for alternate platforms.			
Title: Video-rate Synthetic Aperture Radar (ViSAR) ***Description:*** Recent conflicts have demonstrated the need for close air support by precision attack platforms such as the AC-130J or the MH-60 class helicopters in support of ground forces. Under clear conditions, targets are easily-identified and engaged quite effectively, but in degraded environments the atmosphere is not always clear, and inhibits traditional optical sensors. The AC-130J must fly above cloud decks in order to avoid anti-aircraft fire, and this negates optical targeting sensors. Similarly, rotary/wing blades in urban operations generate copious amounts of dust that block circling assets from supplying cover fire for ground forces. The Video-rate Synthetic Aperture Radar (ViSAR) program will develop a real-time spotlight synthetic aperture radar (SAR) imaging sensor that will provide imagery of a region to allow high-resolution fire direction in conditions where optical sensors do not function. Technology from this program is planned to transition to AFSOC. ***FY 2013 Plans:*** - Initiate hardware design and development of transmitter and receiver components. - Evaluate RF sensor design concepts that will enable high-resolution targeting information through low altitude clouds. - Assess impacts of various platforms and global weather conditions on targeting performance.	-	-	6.500
Title: Autonomous Real-time Ground Ubiquitous Surveillance (ARGUS) * ***Description:*** * Previously called Wide Area Video Surveillance The Autonomous Real-time Ground Ubiquitous Surveillance program is developing airborne sensor systems that provide a persistent, real-time, high-resolution, wide-area, day-night video surveillance capability. The ARGUS Infrared System (ARGUS-IR) uses an advanced infrared (IR) composite focal plane array (CFPA) sensor. The nighttime persistent capability provided by ARGUS-IR combined with the daytime capability provided by the ARGUS Imaging System (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 on a common platform. ARGUS-IR must overcome a number of demanding technical challenges related to the IR Focal Plane Array and size, weight, and power constraints for the IR sensor. A transition plan is being developed with the U.S. Air Force and U.S. Army. ***FY 2011 Accomplishments:*** - Completed the initial design of the IR CFPAs. - Completed the initial development and build of the optics for the IR sensor.	16.000	10.650	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Completed initial software and firmware development. - Completed development of the airborne processing system hardware. ***FY 2012 Plans:*** - Transition ARGUS-IS to the Army as part of the Army/ARGUS-IS/A-160 (AAA) Quick Reaction Capability. - Integrate the IR sensor into the gimbal. - Integrate the IR sensor and airborne processing system onto a designated platform. - Conduct integration and ground testing on a manned platform. - Conduct IR sensor system and airborne processing system qualification and air worthiness testing. - Conduct initial flight testing on a manned and / or unmanned platform. - Transition ARGUS-IR system to the Army and Air Force.			
Title: Advanced Electronic Warfare ***Description:*** The Advanced Electronic Warfare program developed a system that enabled highly precise communications jamming. This program developed and demonstrated robust, low cost, small size, weight, and power (SWaP) distributed electronic warfare (EW) platforms that allow the warfighter to disrupt and impede an adversary's communication network. The program used an array of nodes that have synchronized clocks to enable the signal from each node to be aligned so that the carrier and phase jamming are focused on the specific target area and do not affect the non-target area. Each node contains localization, network, synchronization, and jamming processing and communication in a low-cost, easily deployable package. Technologies developed under this program have been made available to the Services for transition. ***FY 2011 Accomplishments:*** - Conducted initial field experiments using multiple pole-mounted payloads to validate the ability to synchronize and direct energy to an area of interest and extract measurements of performance. - Conducted advanced experiments with improvements in distributed precision clock synchronization and initial multi-node over the air demonstrations with fixed nodes.	7.128	-	-
Title: Large Area Coverage Search-while-Track and Engage (LACOSTE) ***Description:*** The Large Area Coverage Search-while-Track and Engage (LACOSTE) program explored 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 provided wide area surveillance, simultaneous tracking, and target engagement with electro-optical and infrared sensors for tactical GMTI operations. The program developed a sensor with a very wide field of regard, and a wide instantaneous field of view (FOV) that is rapidly scanned in a search-while-track mode, tracking up to thousands of targets in an	2.110	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
urban area. Additionally, the LACOSTE sensor provides next-generation precision tracking to enable engagement on a large number of targets in dense urban areas within that same field of regard with minimal penalty on the search-mode area coverage rate. The program also developed 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 was transitioned to the U.S. Air Force and the U.S. Army at the conclusion of the program. ***FY 2011 Accomplishments:*** - Conducted demonstration of sensitivity, resolution, and tracking.			
Title: NetTrack ***Description:*** The NetTrack Program developed feature-aided tracking technologies to enable airborne surveillance radars to maintain track on moving high value targets (HVTs) in traffic and cluttered environments. Ground moving target indicator (GMTI) radars provide excellent potential for tracking HVTs because they operate in all weather and at long ranges. However, maintaining target tracks is very challenging because obscuration and close target spacing make it difficult to associate radar kinematic measurements over time. To address this challenge, NetTrack developed feature aided tracking technology that automatically collects and exploits target high range resolution (HRR) radar measurements. Specific NetTrack technologies include signal processing to generate HRR measurements from raw radar returns, feature extraction and matching to exploit HRR measurements, multiple hypothesis tracking to associate measurements to tracks and estimate target location and velocity, and sensor resource management to automatically select optimum radar mode parameters and timing sequences. A Memorandum of Agreement (MOA) has been established for transition of NetTrack to the Navy Advanced Airborne Sensor which is a follow-on to the Navy Littoral Surveillance Radar System. ***FY 2011 Accomplishments:*** - Demonstrated feature aided tracking in traffic and cluttered environments. - Collected maritime data and investigated extensions of the NetTrack capabilities to the maritime environment. - Planned and initiated an extension to facilitate an Operational Utility Assessment (OUA) with the Navy. - Developed plans to conduct and carry out several Integration & Test (I&T) flights prior to the OUA demonstration.	2.000	-	-
Title: Precision Inertial Navigation Systems High Dynamic Range Atom Sensors and Systems (PINS HiDRA) ***Description:*** Precision Inertial Navigation Systems High Dynamic Range Atom Sensors and Systems (PINS HiDRA) developed an integrated cold atom-based inertial measurement unit (IMU) suitable for use on a wide range of military platforms. The program built on the work of the Precision Inertial Navigation Systems (PINS) program to dramatically increase the dynamic range of the sensors, thereby enabling operation on aircraft and missiles. Extensive system integration and miniaturization	2.135	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
reduced system size, weight, and power, while increasing navigation performance as measured against currently fielded aircraft inertial navigation systems. Technologies from the PINS HiDRA program have transitioned to the Adaptable Navigation Systems program budgeted at PE 0603767E, SEN-01. ***FY 2011 Accomplishments:*** - Designed system microcontroller and compact laser and optomechanics frame. - Developed computer models for atom sensor operation under high dynamic input and predicted navigation performance under relevant sensor configuration. - Validated sub-system technology selections and incorporated into full six degree-of-freedom inertial sensor design.			
Title: Wide Area Surveillance - Overseas Contingency Operations (OCO) ***Description:*** The Wide Area Surveillance program operationalized wide area surveillance technologies for accelerated transition to DoD programs and systems. Technologies of specific interest included sensor models with sufficient accuracy to support tactical targeting; integrated ground-airborne processing; and advanced processing, exploitation, and dissemination for the ARGUS-IS and ARGUS-IR next generation wide area electro-optical (EO) and IR sensors. Additional capabilities for long duration missions, such as those needed by advanced airships, were also developed. The efforts are transitioning to the Army AAA QRC, Air Force Gorgon Stare QRC, Air Force Blue Devil Block 2 QRC, Air Force Broad Area Surveillance Sensors (BASS) Program, and the Army Long Endurance Multi-Intelligence Vehicle (LEMV) Program. ***FY 2011 Accomplishments:*** - Accelerated the development of the ARGUS-IS Gen 2 processor. - Validated the ARGUS-IS sensor model. - Enhanced ARGUS-IS tactical wide area retrospective persistence for forensics analysis and initiated integration of ARGUS-IS ground processing. - Implemented long duration mission enhancements for ARGUS-IS/ARGUS-IR/AAA. - Accelerated ARGUS-IR development efforts.	38.992	-	-
Accomplishments/Planned Programs Subtotals	109.476	85.495	96.317

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

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E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			DATE: February 2012
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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
SEN-03: *EXPLOITATION SYSTEMS*	62.995	83.999	65.619	-	65.619	55.199	57.013	57.013	60.013	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Insight	37.195	50.205	45.000
Description: Insight is developing the next generation multi-intelligence (multi-INT) exploitation and resource management system. Insight provides new exploitation capabilities through an integrated, standards-based system that is designed for mission flexibility and cross-theater applicability. Insight will enable detection of threat networks and irregular warfare operations through combination and analysis of information from imaging and non-imaging sensors and other sources. The technical approach emphasizes model-based correlation, adversary behavior modeling, threat network analysis tools, resource management tools, a unified data management and processing environment, novel exploitation algorithms and analysis methodologies, and tools to integrate human and machine processing, including visualization, hypothesis manipulation, on-line learning, and distributed social intelligence. Insight development activities leverage both virtual and physical test bed environments. The virtual test bed enables evaluation of alternative sensor mixes and algorithms under extended operating conditions. The physical test bed enables live testing, under realistic operational conditions, using current and next generation sensing and processing systems. Insight technology development is being coordinated with the following potential transition sponsors: Army Program Executive Office-Intelligence, Electronic Warfare & Sensors, Distributed Common Ground System - Army, Army Intelligence and Security Command, Air Force - Distributed Common Ground Station, and the National Geospatial-Intelligence Agency. Insight provides a unified architecture for plug-and-play ISR with extensibility to all Services and Unified Combatant Commands, initially USCENTCOM, USSOCOM, and USPACOM.			
FY 2011 Accomplishments:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Designed and developed the Insight system baseline architecture to support open, modular, software and hardware components; successfully integrated individual components within the baseline architecture. - Designed and developed architectures and interfaces for the virtual test bed, integrating real-world collected data with simulated sensor data, and simulated threats and terrain features. - Designed and developed multi-source exploitation tools for modeling and detection, element discovery and labeling, and multi-INT fusion. - Designed and developed collection and resource management tools to enable dynamic tasking and cross-cueing capabilities. - Designed and developed an analyst-centered, human-machine interface, enabling rich entity representation, efficient information availability, and meaningfully integrated visual perspectives. - Designed and developed the architectures and interfaces for the physical test bed, enabling baseline integrated system capability assessment. - Developed functional and operational use cases to assess baseline integrated system capabilities. - Developed component and system-level measures of performance and effectiveness, e.g., detection and identification, tracking, location accuracy, timeliness of reporting, network detection, anomaly detection, etc. - Performed component and system-level assessments on relevant datasets. - Successfully executed a component integration demonstration to evaluate system readiness for the first field test. ***FY 2012 Plans:*** - Baseline multi-source exploitation, collection and resource management, and human-machine interface techniques against user-validated operational use cases, scenarios, and concepts of operation (CONOPs). - Establish a virtual test bed for baseline testing of system scalability and fidelity, and analysis of alternative CONOPs. - Populate developmental database with additional operationally diverse, real-world collected data to support rapid prototyping of innovative exploitation, resource management, and analytical tools. - Evaluate multi-INT sensor exploitation and control techniques in the virtual test bed. - Conduct a series of increasingly complex system integration demonstrations to validate architectural design. - Perform a limited field test at the physical test bed with participation by operational users and stakeholders to demonstrate unique system functionality, component interoperability, data flow, usability, and operational impact. ***FY 2013 Plans:*** - Conduct a system integration demonstration of functionality and performance. - Perform comprehensive field tests with user and stakeholder communities to validate system operational utility highlighting collection and resource management, and exploitation of data from physical sensors, human sources, and contextual databases. - Demonstrate capabilities including multi-source correlation of vast scale across all information sources; dynamic sensor tasking, cross cueing and handoff; hypothesis management of uncertain data; and inference management to prioritize and explain abnormal behaviors.			

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Integrate the Insight system with live pre-deployment training exercises in coordination with transition partners. - Spin off Insight technologies to fill key capability gaps for existing programs of record. - Conduct virtual test bed exercises to demonstrate exploitation, resource management, visualization, and simulation capabilities. - Conduct a virtual environment challenge to leverage novel approaches to intelligence collection, exploitation, and fusion.			
Title: Wide Area Network Detection (WAND) ***Description:*** The Wide Area Network Detection (WAND) program is developing methods to detect, characterize, and identify threat networks from imaging and other sensors, including national, theater, and organic sensors. Critical performance metrics are timeliness, accuracy, error rates, and interpretation workload. The program addresses the challenges of network/target identification, acquisition, tracking, and denial in difficult environments. The technologies will apply advanced signal processing, sensor fusion, and platform control to leverage advances in sensor capabilities. Transition is planned to the Air Force, Army, and SOCOM. ***FY 2011 Accomplishments:*** - Completed baseline end-to-end system design. - Expanded modeling and simulation environment to include integrated dismount, vehicle, and communication activities in realistic urban scenarios. - Established informal agreement with SOCOM for use of their assets in flight tests. ***FY 2012 Plans:*** - Conduct live-fly data collection to obtain time-coincident wide-area motion imagery (WAMI) and RF detection data. - Complete fabrication of back end processor and demonstrate capability to create accurate WAMI tracks in real time. - Demonstrate improvement in RF geolocation accuracy and transition enhanced RF sensor capability to SOCOM. - Deliver prototype multi-entity geospatial activity correlator to U.S. Army G-2 Army-A160-ARGUS (AAA) Program. - Integrate and demonstrate techniques on Insight testbed. ***FY 2013 Plans:*** - Demonstrate live processing of time-coincident WAMI and RF detection data at CONUS test site. - Demonstrate integrated detection of sites, movements, and communications events associated with threat network activity. - Deliver upgraded multi-entity geospatial activity correlator to U.S. Army G-2 Army-A160-ARGUS (AAA) Program.	10.000	20.874	10.619
Title: Worldwide Intelligence Surveillance and Reconnaissance (WISR) ***Description:*** The Worldwide Intelligence Surveillance and Reconnaissance (WISR) system will provide ISR capability in denied areas. The U.S. military has limited capability or permission to obtain airborne ISR observations of many critical problem areas. Overhead observations are limited by sensor resolution, collection timeline and platform geometry. However, millions of people	-	-	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
worldwide have been recording and posting videos of events and areas of interest for national security. The number of videos available on public networks is rapidly increasing. WISR will use the ground-level video and still images to reconstruct 3-D and 4-D timelines of events and will use these reconstructions to code descriptions of dynamic content, rather than focusing on the identification and movement of individual objects and humans in the scene. WISR constructs will be suitable for describing and differentiating patterns-of-life to reflect local and societal changes. The program will use this data in support of three missions: intelligence preparation for expeditionary forces entering a new area of operation, reconstruction of significant events worldwide, and battle damage assessment. These techniques will transition to operational commands and the intelligence community. ***FY 2013 Plans:*** - Develop and implement techniques for automatically locating and extracting relevant videos and images in a particular area. - Create image understanding techniques to place videos in geographic and chronological context, perform 4-D reconstruction of events, and code the reconstructions based on the dynamic macro-level content of the reconstructions. - Apply image understanding techniques to interpret those reconstructions and videos that meet operator-specified criteria for significant intelligence content.			
Title: Multi-Sensor Exploitation ***Description:*** The Multi-Sensor Exploitation program provides multi-sensor exploitation capabilities enabling missions such as overwatch, border surveillance, high value target tracking, and threat network detection using mixes of imaging, radar, signals, human intelligence, and other sources. The program integrates novel cyber-human-physical sensing and man-machine processing to better take advantage of the strengths of each. New processing techniques for hyperspectral imaging sensors will enable long duration tracking of vehicles and dismounts. Scalable stochastic modeling and inference techniques will yield improved situation awareness and assessment for wide-area electro-optical/IR motion imaging, radar, and multi-sensor exploitation applications in settings where large numbers of interacting entities engaged in complex activities are observed over long periods of time. Techniques intended for use in riverine and maritime environments, where extremist and criminal groups threaten political stability, trade routes, and free commerce, will map navigable tributary systems, detect and identify threats, and monitor their activity. Potential transition partners include USAFRICOM, USSOUTHCOM, USSOCOM and intelligence agencies. ***FY 2011 Accomplishments:*** - Evaluated and optimized techniques and software for tracking targets in dense target environments. - Performed preliminary data collects to establish the viability of novel hyperspectral processing and detection techniques. - Collaborated with several potential transition partners to develop operational concepts utilizing the hyperspectral capability. - Hyperspectral experiments successfully demonstrated proof of concept capability.	6.900	7.720	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
- Tested and refined previously developed detection algorithms to extract thermal spectral signatures of chemical solids and vehicle paints. ***FY 2012 Plans:*** - Demonstrate flow-based tracker improvements using instrumented data and in-theater data. - Develop techniques for dealing with riverine and maritime challenges such as turbidity, multi-path reflection, sea clutter, and high clutter density. - Transition the atmospheric downwelling correction algorithms and the sub-pixel detection algorithms into NGA's operational exploitation configuration.			
Title: Foliage Penetrating Radar Planning and Exploitation ***Description:*** The Foliage Penetrating Radar Planning and Exploitation program will complete final FORESTER foliage penetrating radar demonstrations and provide further exploitation capabilities to find dismounted targets in densely forested terrain. Current foliage penetrating radar systems provide an important capability for detecting dismount targets under foliage, but the systems also detect animals, moving water, blowing trees, and other scene clutter moving under or in the foliage that makes situation assessment, manpower and radar resource intensive. Further, Doppler signature data that may enable improved automated discrimination of dismount targets from other detections is not currently exploited. Finally, no planning tools are available for optimizing and dynamically replanning collection assets to improve imaging geometries and detectability. This program will provide capabilities to address these issues by exploiting Doppler signature data, automating temporal processing approaches currently used, and automating terrain, weather, and on-line exploitation data to enable planning and dynamic replanning. The result will be significantly improved capability for finding and localizing targets under foliage. The program will transition to USSOUTHCOM and USSOCOM. ***FY 2011 Accomplishments:*** - Formulated, evaluated, and optimized algorithms for mitigating detections in radar systems due to non-living objects in motion and for mitigating confusion between humans and animals. - Formulated, evaluated, and optimized multiple algorithms for assessment of group-state activity level sufficient to assist an operator in assessment of the group's intent. ***FY 2012 Plans:*** - Refine algorithms for performing Doppler discrimination and assessing group state and activity. - Optimize and implement algorithms for the FORESTER processing architecture. - Develop pre-mission planning module to optimize flight path for maximum observeability of target named areas of interest. - Transition system into operational exploitation cells.	7.500	5.200	-
Title: Persistent Operations Surface Surveillance and Engagement (POSSE)	1.400	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency		DATE: February 2012
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
Description: The Persistent Operations Surface Surveillance and Engagement (POSSE) program developed 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 has enabled near-real-time generation of the evidence necessary for further investigation or interdiction. POSSE experiments were conducted at the National Training Center (NTC) with realistic role players emulating typical residential, commercial, and light industrial activity. Within this environment, insurgent activity was simulated by qualified experts using the latest and most complete intelligence available. Measurements included precision collections of insurgent activities, as well as the realistic surrounding background clutter of typical civilian activity. Results informed future experiments, led to specifications for future sensor design, and provided insights into how to integrate other narrow and wide area sensors into an integrated approach to countering insurgencies. Transition is in process with the U.S. Army Intelligence and Security Command. ***FY 2011 Accomplishments:*** - Refined sensors specific to close-in insurgent activity detection. - Demonstrated new insurgent activity detection techniques in field exercises at the National Training Center.			
Accomplishments/Planned Programs Subtotals	62.995	83.999	65.619

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2013 Defense Advanced Research Projects Agency			**DATE:** February 2012
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COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
SEN-CLS: *CLASSIFIED*	55.859	63.440	83.087	-	83.087	76.597	76.373	76.532	78.989	Continuing	Continuing

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Title: Classified DARPA Program ***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2011 Accomplishments:*** Details will be provided under separate cover. ***FY 2012 Plans:*** Details will be provided under separate cover. ***FY 2013 Plans:*** Details will be provided under separate cover.	55.859	63.440	83.087
Accomplishments/Planned Programs Subtotals	55.859	63.440	83.087

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

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Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	74.469	-	-	-	-	-	-	-	-	Continuing	Continuing
SB-01: *SMALL BUSINESS INNOVATIVE RESEARCH*	74.469	-	-	-	-	-	-	-	-	Continuing	Continuing
Quantity of RDT&E Articles											

A. Mission Description and Budget Item Justification

In accordance with Public Law No: 112-17 (Small Business Reauthorization Act) and Small Business Technology Transfer Program Reauthorization Act, 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 enable fundamental discoveries and technological breakthroughs that provide new military capabilities.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	-	-	-	-	-
Current President's Budget	74.469	-	-	-	-
Total Adjustments	74.469	-	-	-	-
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	74.469	-			

Change Summary Explanation

FY 2011: Increase reflects SBIR/STTR transfer.

C. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Small Business Innovative Research ***Description:*** 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 enable fundamental discoveries and technological breakthroughs that provide new military capabilities.	74.469	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605502E: *SMALL BUSINESS INNOVATIVE RESEARCH*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
FY 2011 Accomplishments: The DARPA SBIR and STTR programs were executed within OSD guidelines.			
Accomplishments/Planned Programs Subtotals	74.469	-	-

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

Not applicable.

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605897E: *DARPA AGENCY RELOCATION*

COST ($ in Millions)	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	12.344	1.000	-	-	-	-	-	-	-	Continuing	Continuing
AR-02: *DARPA AGENCY RELOCATION*	12.344	1.000	-	-	-	-	-	-	-	Continuing	Continuing
Quantity of RDT&E Articles											

A. Mission Description and Budget Item Justification

This Program Element is budgeted in the Management Support Budget Activity because it is funding the building relocation support cost requirements for the Defense Advanced Research Projects Agency (DARPA). The move to a new facility is in response to 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 is mandatory for facilities leased for DoD use and 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 extends beyond October 2009. 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 2012.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	11.000	1.000	-	-	-
Current President's Budget	12.344	1.000	-	-	-
Total Adjustments	1.344	-	-	-	-
• Congressional General Reductions	-0.056	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	1.400	-			
• SBIR/STTR Transfer	-	-			

Change Summary Explanation

FY 2011: Increase reflects below threshold reprogramming to complete the tenant build out activities offset by the reduction for the Section 8117 Economic Adjustment.

C. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: DARPA Agency Relocation	12.344	1.000	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	DATE: February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605897E: *DARPA AGENCY RELOCATION*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2011	FY 2012	FY 2013
Description: DARPA Agency Relocation ***FY 2011 Accomplishments:*** - Initiated tenant build out to include: unclassified office space, Sensitive Compartmented Information Facilities (SCIFs), conference center, wiring closets, building security system, unclassified and classified cabling, and all associated activities to prepare the building for occupancy. - Outfitted offices, conference rooms, and conference center with IT equipment. ***FY 2012 Plans:*** - Complete move and restoration of current facility in accordance with lease requirements.			
Accomplishments/Planned Programs Subtotals	12.344	1.000	-

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	56.393	66.689	69.767	-	69.767	71.640	73.236	75.170	77.455	Continuing	Continuing
MH-01: *MANAGEMENT HQ - R&D*	56.393	66.689	69.767	-	69.767	71.640	73.236	75.170	77.455	Continuing	Continuing
Quantity of RDT&E Articles											

A. Mission Description and Budget Item Justification

This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical security, travel, supplies and equipment, communications, printing and reproduction.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	56.257	66.689	70.090	-	70.090
Current President's Budget	56.393	66.689	69.767	-	69.767
Total Adjustments	0.136	-	-0.323	-	-0.323
• Congressional General Reductions	-0.808	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-1.756	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	2.700	-			
• SBIR/STTR Transfer	-	-			
• TotalOtherAdjustments	-	-	-0.323	-	-0.323

Change Summary Explanation

FY 2011: Increase reflects a below threshold reprogramming offset by the reduction for Section 8117 Economic Adjustment, rescissions and the Section 8118 civilian pay adjustment.

FY 2013: Decrease reflects minor repricing.

C. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Management Headquarters ***Description:*** Management Headquarters ***FY 2011 Accomplishments:***	56.393	66.689	69.767

Exhibit R-2, RDT&E Budget Item Justification: PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605898E: *MANAGEMENT HQ - R&D*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
- Funded civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs. - Funded travel, rent and other infrastructure support costs. - Funded security costs to continue access controls, uniformed guards, and building security requirements. - Funded CFO Act compliance costs. - Funded DARPA share of DoD Acquisition Workforce Fund. ***FY 2012 Plans:*** - Fund civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs. - Fund travel, rent and other infrastructure support costs. - Fund security costs to continue access controls, uniformed guards, and building security requirements. - Fund CFO Act compliance costs. - Fund DARPA share of DoD Acquisition Workforce Fund. ***FY 2013 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.			
Accomplishments/Planned Programs Subtotals	56.393	66.689	69.767

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
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 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total	FY 2014	FY 2015	FY 2016	FY 2017	Cost To Complete	Total Cost
Total Program Element	9.949	5.000	1.801	-	1.801	-	-	-	-	Continuing	Continuing
CYB-01: *CYBER SECURITY INITIATIVE*	9.949	5.000	1.801	-	1.801	-	-	-	-	Continuing	Continuing
Quantity of RDT&E Articles											

A. Mission Description and Budget Item Justification

The National Cyber Security Initiative will foster a revolution in the Nation's ability to protect and defend its cyber operations. DARPA's responsibility as part of the overall Cyber Security Initiative (CSI) is to create a cyber test range that will become a National resource for testing the resiliency of cyber programs in the face of hostile action. The Cyber Range will be capable of supporting multiple, simultaneous, segmented tests in realistically configured or simulated testbed environments.

B. Program Change Summary ($ in Millions)

	FY 2011	FY 2012	FY 2013 Base	FY 2013 OCO	FY 2013 Total
Previous President's Budget	10.000	10.000	10.000	-	10.000
Current President's Budget	9.949	5.000	1.801	-	1.801
Total Adjustments	-0.051	-5.000	-8.199	-	-8.199
• Congressional General Reductions	-0.051	-			
• Congressional Directed Reductions	-	-5.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• TotalOtherAdjustments	-	-	-8.199	-	-8.199

Change Summary Explanation

FY 2011: Decrease reflects reduction for the Section 8117 Economic Adjustment.
FY 2012: Decrease reflects reduction for execution delays.
FY 2013: Decrease reflects re-prioritization of the Comprehensive National Cyber Initiative.

C. Accomplishments/Planned Programs ($ in Millions)

	FY 2011	FY 2012	FY 2013
Title: Cyber Security Initiative ***Description:*** The goal of the Cyber Security Initiative is to revolutionize the Nation's ability to conduct cyber operations by developing a persistent and cost-effective cyber testing environment. The National Cyber Range (NCR) program will develop	9.949	5.000	1.801

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2013 Defense Advanced Research Projects Agency	**DATE:** February 2012
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0305103E: *CYBER SECURITY INITIATIVE*

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2011**	**FY 2012**	**FY 2013**
a network testbed that will allow for research experimentation on diverse hardware and software topologies to produce qualitative and quantitative assessments of cyber security research and development programs through a safe, instrumented experimentation environment. The range will replicate complex, heterogeneous networks. It will revolutionize cyber testing to enable efficient cyber experimentation and facilitate realistic testing of tools and techniques to enable high fidelity assessments of cyber tools and techniques and the rapid transition of research programs to operations. This program will begin transition to the U.S. Cyber Command (USCYBERCOM) and will be available for leverage or use by all Federal Government organizations. ***FY 2011 Accomplishments:*** - Completed NCR prototype development. - Initiated the development of a business model to operate the NCR prototype. ***FY 2012 Plans:*** - Commence NCR prototype testing and cyber experimentation. - Continue to develop and test relevant technologies to improve the functionality of the NCR. - Commence transition of NCR to USCYBERCOM. ***FY 2013 Plans:*** - Transition NCR technologies to government customers.			
Accomplishments/Planned Programs Subtotals	9.949	5.000	1.801

D. Other Program Funding Summary ($ in Millions)

N/A

E. Acquisition Strategy

N/A

F. Performance Metrics

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