Department of Defense
Fiscal Year (FY) 2014 President's Budget Submission

April 2013

Defense Advanced Research Projects Agency

Justification Book Volume 1 of 1

Research, Development, Test & Evaluation, Defense-Wide

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Table of Volumes

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Department of Defense
FY 2014 President's Budget
Exhibit R-1 FY 2014 President's Budget
Total Obligational Authority
(Dollars in Thousands)

11 Mar 2013

Appropriation	FY 2012 (Base & OCO)	FY 2013 Base Request with CR Adj*	FY 2013 OCO Request with CR Adj*	Emergency Disaster Relief Act of 2013	FY 2013 Total Request with CR Adj*	FY 2014 Base
Research, Development, Test & Eval, DW	2,814,078	2,817,176			2,817,176	2,865,087
Total Research, Development, Test & Evaluation	2,814,078	2,817,176			2,817,176	2,865,087

R-1C: FY 2014 President's Budget (Published Version), as of March 11, 2013 at 12:16:06
* Reflects the FY 2013 President's Budget with an undistributed adjustment to match the Annualized Continuing Resolution funding level by appropriation.

Department of Defense
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Summary Recap of Budget Activities	FY 2012 (Base & OCO)	FY 2013 Base Request with CR Adj*	FY 2013 OCO Request with CR Adj*	Emergency Disaster Relief Act of 2013	FY 2013 Total Request with CR Adj*	FY 2014 Base
Basic Research	327,763	348,727			348,727	364,533
Applied Research	1,188,288	1,174,673			1,174,673	1,205,017
Advanced Technology Development	1,152,108	1,222,208			1,222,208	1,223,878
Management Support	145,919	71,568			71,568	71,659
Total Research, Development, Test & Evaluation	2,814,078	2,817,176			2,817,176	2,865,087

Summary Recap of FYDP Programs	FY 2012 (Base & OCO)	FY 2013 Base Request with CR Adj*	FY 2013 OCO Request with CR Adj*	Emergency Disaster Relief Act of 2013	FY 2013 Total Request with CR Adj*	FY 2014 Base
Intelligence and Communications	3,471	1,801			1,801	
Research and Development	2,810,607	2,815,375			2,815,375	2,865,087
Total Research, Development, Test & Evaluation	2,814,078	2,817,176			2,817,176	2,865,087

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

Line No	Program Element Number	Item	Act	FY 2012 (Base & OCO)	FY 2013 Base Request with CR Adj*	FY 2013 OCO Request with CR Adj*	Emergency Disaster Relief Act of 2013	FY 2013 Total Request with CR Adj*	FY 2014 Base	Sec
2	0601101E	Defense Research Sciences	01	283,318	309,051			309,051	315,033	U
4	0601117E	Basic Operational Medical Research Science	01	44,445	39,676			39,676	49,500	U
		Basic Research		327,763	348,727			348,727	364,533	
9	0602115E	Biomedical Technology	02	95,661	110,900			110,900	114,790	U
14	0602303E	Information & Communications Technology	02	343,383	392,421			392,421	413,260	U
15	0602304E	Cognitive Computing Systems	02	46,020	30,424			30,424	16,330	U
16	0602305E	Machine Intelligence	02	49,717						U
17	0602383E	Biological Warfare Defense	02	30,844	19,236			19,236	24,537	U
22	0602702E	Tactical Technology	02	202,735	233,209			233,209	225,977	U
23	0602715E	Materials and Biological Technology	02	203,826	166,067			166,067	166,654	U
24	0602716E	Electronics Technology	02	216,102	222,416			222,416	243,469	U
		Applied Research		1,188,288	1,174,673			1,174,673	1,205,017	
37	0603286E	Advanced Aerospace Systems	03	94,303	174,316			174,316	149,804	U
38	0603287E	Space Programs and Technology	03	99,138	159,704			159,704	172,546	U
55	0603739E	Advanced Electronics Technologies	03	144,047	111,008			111,008	117,080	U
57	0603760E	Command, Control and Communications Systems	03	246,476	237,859			237,859	239,078	U
58	0603765E	Classified DARPA Programs	03	104,662	3,000			3,000		U
59	0603766E	Network-Centric Warfare Technology	03	195,582	236,883			236,883	259,006	U
60	0603767E	Sensor Technology	03	267,900	299,438			299,438	286,364	U
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156	0605502E	Small Business Innovative Research	06	74,759						U
163	0605897E	DARPA Agency Relocation	06	1,000						U
164	0605898E	Management HQ - R&D	06	66,689	69,767			69,767	71,659	U
174	0305103E	Cyber Security Initiative	06	3,471	1,801			1,801		U
		Management Support		145,919	71,568			71,568	71,659	
		Total Research, Development, Test & Eval, DW		2,814,078	2,817,176			2,817,176	2,865,087	

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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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	283.318	309.051	315.033	-	315.033	310.494	314.123	330.807	337.544	Continuing	Continuing
BLS-01: *BIO/INFO/MICRO SCIENCES*	-	30.463	39.678	29.771	-	29.771	29.248	33.250	40.925	41.625	Continuing	Continuing
CCS-02: *MATH AND COMPUTER SCIENCES*	-	58.153	72.480	72.073	-	72.073	72.290	75.812	86.729	87.451	Continuing	Continuing
CYS-01: *CYBER SCIENCES*	-	16.200	25.000	33.333	-	33.333	32.667	40.000	0.000	0.000	Continuing	Continuing
ES-01: *ELECTRONIC SCIENCES*	-	36.528	50.103	46.876	-	46.876	45.876	36.876	49.376	51.752	Continuing	Continuing
MS-01: *MATERIALS SCIENCES*	-	100.165	86.540	82.819	-	82.819	75.186	73.824	84.877	90.263	Continuing	Continuing
TRS-01: *TRANSFORMATIVE SCIENCES*	-	41.809	35.250	50.161	-	50.161	55.227	54.361	68.900	66.453	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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.

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*

The Cyber Sciences project supports long term national security requirements through scientific research and experimentation in cyber-security. Networked computing systems control virtually everything, from power plants and energy distribution, transportation systems, food and water distribution, financial systems, to defense systems. Protecting the infrastructure on which these systems rely is a national security issue. The Cyber Sciences project will ensure DoD cyber-capabilities survive adversary attempts to degrade, disrupt, or deny military computing, communications, and networking systems. Basic research in cyber security is required to provide a basis for continuing progress in this area. Promising research results will transition to both technology development and system-level projects.

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

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

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

B. Program Change Summary ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014 Base**	**FY 2014 OCO**	**FY 2014 Total**
Previous President's Budget	290.773	309.051	315.567	-	315.567
Current President's Budget	283.318	309.051	315.033	-	315.033
Total Adjustments	-7.455	0.000	-0.534	-	-0.534
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.503	0.000			
• SBIR/STTR Transfer	-7.958	0.000			
• TotalOtherAdjustments	-	-	-0.534	-	-0.534

Change Summary Explanation

FY 2012: Decrease reflects reductions for the SBIR/STTR transfer offset by a minor reprogramming.

FY 2014: Decrease reflects minor program repricing.

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
BLS-01: *BIO/INFO/MICRO SCIENCES*	-	30.463	39.678	29.771	-	29.771	29.248	33.250	40.925	41.625	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Bio Interfaces	5.750	12.000	11.832
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 2012 Accomplishments:*** - Identified genomic and epigenomic signatures that dictate spatio-temporal regulation of temporal processes such as cell cycle progression, metabolic cycles, and lifespan using bioinformatic or data mining techniques as a stepping stone to understanding the nature of time in biology and medicine. - Developed 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.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Synthesized the minimal set of genomic, proteomic, transcriptomic, or epigenomic input data required for the creation of a predictive algorithm. ***FY 2013 Plans:*** - Define 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 (e.g., sleep cycles, metabolic cycles, and disease outbreak cycles). - 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. ***FY 2014 Plans:*** - Experimentally validate canonical spatio-temporal episequences, and develop a minimal dataset for accurate predictions of temporal processes such as cell cycle progression, metabolic cycles, and lifespan. - Refine predictive algorithms of the progression of biological time. - Develop and test the predictive model or algorithm against a blind panel to predict doubling time, cell cycle progression, metabolism and lifespan metrics.			
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). A key new antibody technology will develop the ideal antibody master molecule for use in unattended sensors that maintains high temperature stability and controllable affinity for threat agents. Applications to Defense systems include the development of chemical and biological sensors; tools for strategic military decision-makers involved in information operations, and improved warfighter battlefield survivability. ***FY 2012 Accomplishments:*** - Combined 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.	4.893	8.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Explored and refined foundational assumptions on the utility of the Freytag and other structures for narrative analysis, including determining relationships between decomposed narratives and neuropsychological mechanisms, and between narratives and behavior. - Developed decomposition frameworks and initial cluster of neurobiological mechanisms to better understand their relationship. - Developed tools to link analytic frameworks, neural mechanisms, and environmental variables to particular narratives. ***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. - Incorporate findings about the neurobiology of culture-dependent and culture-independent variables into models and simulations of narrative influence. - Refine sensor suite technologies.			
Title: Quantitative Models of the Brain* ***Description:*** *Formerly Mathematics of the Brain The Quantitative Models of the Brain program will develop a new mathematical paradigm for understanding how to model reasoning processes for application to a variety of emerging DoD challenges. Critical to this endeavor will be determining how information is stored and recalled in the brain and developing predictive, quantitative models of learning and memory. Using this understanding, 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 extract and leverage information in signals at multiple acquisition levels, which would fundamentally generalize compressive sensing for multi-dimensional sources beyond domains typically used. New insights related to signal priors, task priors, and adaptation will enable these advances. 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. The quantitative models of learning and memory will also lead to improvements in the training of individuals and teams as well as advances in cognitive rehabilitation (e.g. PTSD). ***FY 2012 Accomplishments:*** - Developed detailed mathematical prior-knowledge representations and associated models for imaging and radar applications. - Exploited 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.	10.370	12.000	10.439

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated 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. ***FY 2014 Plans:*** - Demonstrate hyperspectral imaging using 100x fewer measurements than reconstructed voxels. - Explore application of compressive sensing concepts to alternate sensing modalities such as X-ray imaging. - Investigate the potential gains available from compressive sensing within a video application. - Leverage advances in neuroscience and neurological measurements to develop predictive, quantitative models of memory, learning, and neuro-physiologic recovery.			
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. Finally, the quantum phenomena uncovered will be exploited to control the attraction of insects to humans with the potential to completely eliminate insect bites and thus the transmission of parasitic, bacterial or viral pathogens. ***FY 2012 Accomplishments:*** - Developed theory and performed simulations for the transduction of the magnetoreception signal on the visual field. - Developed concepts and initial designs for sensors inspired by biological quantum effects. - Developed a general theory for photosynthetic transport, governed by a single parameter, that shows that it is an example of a quantum 'Goldilocks effect', i.e., the degree of quantum complexity and coherence is 'just right' for attaining maximum efficiency. - Formulated a new concept of "excitonic circuits" (that concentrate and direct excitons as in photosynthesis) and designed generic circuit elements.	9.450	7.678	7.500

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
- Verified that molecular vibrations, and thus quantum effects, are essential to describing olfaction. ***FY 2013 Plans:*** - Develop prototype synthetic sensors that utilize biologically inspired quantum effects and model their performance. - Demonstrate the ability to control quantum effects in biological systems by reorienting magnetoreception through the radical pair mechanism using radio frequency fields. - Demonstrate the biological and evolutionary advantage of quantum effects in photosynthetic systems. ***FY 2014 Plans:*** - Demonstrate prototype quantum biological sensors against their equivalent state-of-the-art sensor and quantify the increase in sensitivity, selectivity and other performance metrics. - Explore quantum physics-based mechanisms of mosquito bio-sensing related to mosquito attraction to humans for novel, vector-born disease protection against diseases such as malaria or dengue fever.			
Accomplishments/Planned Programs Subtotals	30.463	39.678	29.771

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013

APPROPRIATION/BUDGET ACTIVITY	**R-1 ITEM NOMENCLATURE**	**PROJECT**
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	PE 0601101E: *DEFENSE RESEARCH SCIENCES*	CCS-02: *MATH AND COMPUTER SCIENCES*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
CCS-02: *MATH AND COMPUTER SCIENCES*	-	58.153	72.480	72.073	-	72.073	72.290	75.812	86.729	87.451	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Computer Science Study Group (CSSG)	11.169	5.100	4.050
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 2012 Accomplishments:*** - Transitioned successful research outcomes from Classes 2008-2011. - Awarded grants to ten Principal Investigators (PIs) from the Class of 2011 in support of research with high payoff potential to DoD. - Awarded grants to five PIs for transition of their research to the DoD and intelligence community, in partnerships with other sources of funding from government or industry. ***FY 2013 Plans:*** - Transition successful research outcomes from Classes 2009-2011.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- 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. ***FY 2014 Plans:*** - Transition successful research outcomes from Classes 2010-2011.			
Title: Young Faculty Award (YFA) ***Description:*** The goal of the Young Faculty Award (YFA) program is to encourage junior faculty at universities and their equivalent at non-profit science and technology research 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 and defense sciences. The long-term goal for this program is to develop the next generation of scientists, engineers, and mathematicians in key disciplines who will focus a significant portion of their careers on DoD and National Security issues. Beginning in 2013, YFA technical topic areas are more closely tied to programs currently underway at DARPA and to recently identified DoD and National Security needs. The aim is for YFA recipients to receive deep interactions with DARPA program managers, programs, performers, and the user community. Current activities include research in thirteen topic areas spanning from Quantum Science and Technology to Robotics and Supervised Autonomy, Mathematics, Computing, and the interface of Engineering and Biology. 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 2012 Accomplishments:*** - Exercised second year options for selected FY2011 participants to continue research focused on new concepts for microsystem technologies, innovative information technologies, and defense sciences. - Awarded FY2012 grants for new two-year research efforts across the topic areas. - Established approaches to bring appropriate technologies developed through YFA to bear on relevant DoD problems. - Continued 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 FY2013 grants for new two-year research efforts across the topic areas. - Establish and improve approaches to bring appropriate technologies developed through YFA to bear on relevant DoD problems. - Continue and improve mentorship by program managers and engagement with DARPA to encourage future work that focuses on DoD needs. ***FY 2014 Plans:***	13.000	15.450	16.500

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
- Exercise second year options for FY2013 participants to continue research focused on new concepts for microsystem technologies and defense sciences. - Award FY2014 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 that focuses 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 2012 Accomplishments:*** - Initiated the development of robust simulator technologies that generate realistic SSIM-oriented training scenarios and user challenges, automate the evaluation of user responses, and support semi-automated expert authoring/editing of scenarios. - Conceptualized processes for deploying the SSIM-based training simulator to the U.S. Marine Corps and the Washington State Criminal Justice Training Commission (transition partners) and the U.S. Army and SOCOM (possible transition partners). - Extended the social complexity of the training scenarios to include engagements that transition to and from kinetic actions. - Developed initial techniques for assessing a trainee's learning during simulation. - Created basic curricula for SSIM-based training. ***FY 2013 Plans:*** - Test accuracy of non-player-character reactions to trainee's actions and behaviors. - Develop methods to evaluate the effectiveness of SSIM-trained warfighters during interpersonal interactions with local populations. - Enhance the video-capture and analysis of trainees' interactions during tasks that require cross cultural interactions. ***FY 2014 Plans:***	10.700	13.600	14.870

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Refine the curriculum for SSIM-oriented training based on findings regarding effective social interaction. - Extend the assessment of the effectiveness of SSIM-training to determine direct and indirect effects. - Deploy the SSIM-based training and training simulator to transition partners.			
Title: Engage ***Description:*** The Engage program develops on-line approaches for complex problem solving in real-world settings by analyzing and adapting performance across large numbers of users. Using unconventional mechanisms and incentives, Engage will create an on-line environment for data-driven, interactive, multidisciplinary collaboration between experts and non-experts to address heretofore insolvable DoD challenge problems. This big-data analysis approach will identify optimum training strategies and result in the development of software that is highly individualized to the user. 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 on-line training. ***FY 2012 Accomplishments:*** - Developed software infrastructure for a training environment that allows the methods of instruction to be varied in order to determine the best approaches. - Analyzed methodologies using statistics based on data drawn from a large interactive training environment. - Developed and released Engage-based software for training a variety of technical topics. ***FY 2013 Plans:*** - Improve the problem-solving training platform based on the initial research results. - Re-implement the various application domain software components using the improved platform. - Continue analysis of methodologies using statistics based on data drawn from a large interactive environment. - Analyze and assess changes to existing Engage-based software when applied to different student age groups. - Transition the first phase of Engage-based software to relevant DoD training activities. ***FY 2014 Plans:*** - Develop and release Engage-based software for training additional topics. - Continue transition efforts to include dissemination of Engage-based software based on lessons learned from relevant DoD training activities. - Establish a collaborative, on-line, problem-solving environment that allows experts and non-experts to address complex DoD challenge problems.	7.000	8.150	11.800
Title: Mathematics of Sensing, Exploitation and Evaluation (MSEE) ***Description:*** The Mathematics of Sensing, Exploitation and Evaluation (MSEE) program seeks to create a comprehensive mathematical theory of information processing, strategy formulation and decision determination. Such a theory would incorporate	8.000	11.000	7.853

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
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 2012 Accomplishments:*** - Incorporated stochastic models and statistical reasoning to understand the nature of computations in human minds. - Explored open system concepts capable of demonstrating the ability to process information and determine best available responses, subject to time-varying context. - Quantified 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 of a prototype automated surveillance system that will be tuned to respond to events of military relevance; formulate and calculate performance metrics that quantify expected performance gains. - Design and prototype an 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. ***FY 2014 Plans:*** - Implement multiple-modality solutions that will demonstrate effectiveness of a unified approach to sensing. - Create an advanced evaluation test-bed that will enable probative, quantitative assessment of a system's ability to understand scene semantics. - Demonstrate enhanced anomaly detection under varying operating conditions, including production of a single (unified) semantic representation of a scene in the presence of coincident sensor data coming from multiple modalities, only some of which may comprise electro-optical/IR .			
Title: Unconventional Processing of Signals for Intelligent Data Exploitation (UPSIDE)* ***Description:*** *Formerly Unconventional Computation	0.000	10.000	17.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
The Unconventional Processing of Signals for Intelligent Data Exploitation (UPSIDE) program will address the open problems facing real-time ISR systems and other power-constrained data-intensive applications. The objective of the UPSIDE program is to create a high-level, non-Boolean computational model and map it directly to the unique functional properties of new emerging devices to achieve significant increases in power efficiency and performance. The UPSIDE program will create a new generation of computing structures that will, in turn, enable revolutionary advances in ISR processing, particularly for DoD applications of embedded, real-time sensor data analysis. Because Boolean data representations are inherently power-inefficient for many datasets, particularly those produced by noisy analog real-time sensors, the UPSIDE program will establish an unconventional, non-Boolean, computing paradigm to enable new and needed capabilities in the area of sensor data analysis. UPSIDE intends to implement this new computing paradigm in the form of a specialized hardware component termed the inference module (IM). The inference module will be first developed through simulation, and then implemented using mixed-signal complementary metal-oxide semiconductor (CMOS), as well as using state of the art emerging (non-CMOS) devices. Throughout the program, the inference module will be benchmarked using a DoD relevant image processing pipeline, to verify gains in both computing throughput and power efficiency. The result will be a computing infrastructure and functional implementations that demonstrate three orders of magnitude improvement in processing speed and four orders of magnitude improvement in power efficiency. These gains will constitute a disruptive new level of embedded computational efficiency for future real-time sensor systems. ***FY 2013 Plans:*** - Define unconventional (non-Boolean) computing methodology and inference module abstraction. - Identify target recognition and tracking application. - Create conventional image processing pipeline simulation for baseline comparison of UPSIDE image processing metrics. - Initiate design of a mixed-signal complementary metal-oxide semiconductor (CMOS) chip-based inference module architecture. - Develop the emerging device simulations and specifications necessary to begin work on an emerging device based inference module. ***FY 2014 Plans:*** - Simulate the selected image processing pipeline utilizing the previously developed inference methodology. - Develop mixed-signal CMOS based image processing pipeline simulation and validate the simulation using real-time, high-definition video streams. - Design and fabricate mixed-signal CMOS chip implementation of inference module. - Fabricate and demonstrate simple circuits based on emerging devices for future inference module development. - Begin development of CMOS support chip for emerging devices.			
Title: Graph-theoretical Research in Algorithm Performance & Hardware for Social networks (GRAPHS)	8.284	9.180	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
Description: 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 that characterizes social networks of DoD interest, and includes a description of how these quantities vary in both space and time. ***FY 2012 Accomplishments:*** - Created an enhanced network modeling theory that incorporates ability to perform spatiotemporal analysis. - Investigated impact of replacing generic network nodes with human agents whose behavior can be modeled statistically. - Performed small-scale analyses of dynamic networks and demonstrate ability to recognize event precursors. - Identified 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. - 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.			
Accomplishments/Planned Programs Subtotals	58.153	72.480	72.073

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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*

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 2014 Defense Advanced Research Projects Agency			**DATE:** April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** CYS-01: *CYBER SCIENCES*	

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
CYS-01: *CYBER SCIENCES*	-	16.200	25.000	33.333	-	33.333	32.667	40.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 significant elements of critical national infrastructure, from power plants and energy distribution grids, transportation systems, food and water distribution systems, and financial networks to defense systems. During 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 lone miscreants, have grown rapidly in sophistication and number. The Cyber Sciences project will ensure DoD resilience in the face of 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 2012	FY 2013	FY 2014
Title: Active Authentication	5.033	10.200	14.500

Description: 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 Accomplishments:
- Analyzed methods for determining user identity from behavioral cues.
- Prototyped software biometric approaches that integrate cognitive features associated with the use of input/output devices and the use of written language in e-mails or other documents.
- Validated the viability of biometric approaches through testing.
- Formulated new access control mechanisms that incorporate a probabilistic measure of user identity.

FY 2013 Plans:
- Develop open application programming interfaces (APIs) to allow the ready integration of third-party software and hardware biometrics.
- Initiate development of a new authentication platform suitable for deployment on DoD hardware.

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** CYS-01: *CYBER SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Implement multiple advanced authentication mechanisms in one or more prototype systems suitable for use on DoD networks. ***FY 2014 Plans:*** - Demonstrate enhanced authentication using multiple biometrics representing complementary aspects of the individual. - Evaluate the level of confidence that is achievable using multiple advanced authentication mechanisms and quantify the resulting level of security using red teaming and other techniques. - Prototype a new authentication platform suitable for use on major DoD platforms in collaboration with potential transition sponsors.			
Title: Automated Program Analysis for Cybersecurity (APAC) ***Description:*** 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 Accomplishments:*** - Developed a collection of specific security properties that demonstrated a mobile application is not malicious. - Developed automated program analysis techniques for determining whether or not mobile applications had specific security properties and implemented these techniques in prototype tools. - Extracted relevant classes of malicious techniques from publicly available malware. ***FY 2013 Plans:*** - Conduct competitions to stress the capabilities incorporated in prototype tools. - Create increasingly effective prototype tools and specific properties from the results of the competitions. - 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. ***FY 2014 Plans:*** - Improve the effectiveness of prototype tools and specific properties through further competitions. - Use measurements against the program metrics to identify prototype tools that are likely candidates for technology transition. - Refine tools in response to transition partner challenges.	11.167	14.800	18.833
Accomplishments/Planned Programs Subtotals	16.200	25.000	33.333

Exhibit R-2A, **RDT&E Project Justification:** PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** CYS-01: *CYBER SCIENCES*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency		DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** ES-01: *ELECTRONIC SCIENCES*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
ES-01: *ELECTRONIC SCIENCES*	-	36.528	50.103	46.876	-	46.876	45.876	36.876	49.376	51.752	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
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, spatially coherent X-ray sources 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 techniques 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 from blunt trauma without the injection of a contrast enhancing agent. The radiation dose required for imaging will also be reduced. 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 imaging field based on tunable x-ray wavelengths. This program also has related applied research efforts funded under PE 0602716E, Project ELT-01.	5.500	9.800	10.500

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 1: *Basic Research*	**R-1 ITEM NOMENCLATURE** PE 0601101E: *DEFENSE RESEARCH SCIENCES*	**PROJECT** ES-01: *ELECTRONIC SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Established physical and design limitations for compact energy-efficient X-ray sources. - Demonstrated the feasibility of key enabling components (cathodes, accelerators, radiators & lasers) for compact energy-efficient x-ray sources. - Investigated fundamental issues pertinent to the generation of coherent X-rays through emittance exchange & Inverse Compton Scattering (ICS), and optically driven acceleration & free electron lasing. - Developed a Laser Wakefield Plasma electron accelerator and demonstrated the ability to produce X-rays from Betatron oscillations and explored phase contrast imaging of small objects with the x-ray source. - Developed and demonstrated novel approaches, including plasmonic enhancement, to high-performance cathode design and fabrication. - Developed and demonstrated the viability of pyroelectric-based next-generation electron emitters. - Demonstrated the feasibility of generating X-rays by means of channeling radiation. ***FY 2013 Plans:*** - Fabricate and demonstrate arrays of closely spaced electron sources with short pulse durations and low emittance for generating small charge bunches. - Fabricate and demonstrate dielectric structures (dielectric loaded waveguides) for accelerating electron bunch to relativistic energies. - Develop ultra-compact short pulse (<1 picosecond), high repetition rate and high power lasers employing saturable gain media. - Demonstrate microfabrication of permanent-magnet-based undulators for x-ray generation. - Demonstrate the utility of coded apertures for generation of phase contrast imaging. ***FY 2014 Plans:*** - Demonstrate a compact, high-brilliance and low-power x-ray source by integrating low-emittance electron sources, laser dielectric accelerators and laser dielectric undulators. - Demonstrate a compact, high-brilliance and low-power x-ray source using high finesse optical cavities, dielectric loaded waveguides and dielectric structures. - Fabricate devices that generate X-rays through channeling radiation. - Successfully demonstrate a compact, low-power device capable of generating phase contrast images.			
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	2.000	3.500	5.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014

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 Accomplishments:
- Defined initial microscale plasma device (MPD) design parameters and signal processing architectures.
- Generated plasma at ultra-high (1-20 atmosphere) pressures with emphasis on robust electronic switching.
- Achieved plasma carrier density exceeding one times ten to the twentieth power (1E20)/cubic centimeters, exceeding the program goals (1E18) by two orders of magnitude.
- Achieved MPD switching speed of less than 250 picoseconds, and determined plasma gas pressures necessary to reach the program goal of less than 100 picosecond speeds, needed for robust survivability in high power electromagnetic fields.
- Began characterization of high-temperature (600 degrees Celsius) effects on microscale plasma device materials and substrates.
- Designed and began optimization of microscale plasma devices (1-20 micrometer scale microcavities) for implementation in substrate systems.
- Began characterization of fundamental MPD device reliability in extreme radiation environments, consistent with nuclear reactors.
- Demonstrated microscale plasma device operation exceeding 2 hours in environments that destroy complementary metal-oxide semiconductor (CMOS) devices within minutes.
- Achieved greater than 2000 hour microscale plasma device lifetime with no visible damage to microplasma cavity system.

FY 2013 Plans:
- Optimize plasma cavity environment for plasma generation at ultra-high (1-20 atm) pressures with emphasis on robust electronic switching.
- Improve robustness of microscale plasma devices with carrier density exceeding ten to the eighteenth power/cubic centimeter.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Continue to investigate effects of high temperature environments on plasma generation and microscale devices at temperatures up to 600 degrees Celsius. - Determine optimal parameters including gas pressure and mixture necessary for < 100 picosecond MPD switching speeds needed for robust survivability in high power electromagnetic fields. - Improve robustness of MPD devices operating in extreme radiation environments to improve average lifetime orders of magnitude beyond state of art radiation hardened CMOS. - Generate high-power microwave through Terahertz (Thz) frequency signals utilizing plasma as a non-linear up-conversion medium. ***FY 2014 Plans:*** - Complete optimized microcavity designs achieving parameters and uniformity necessary for < 100 picosecond device switching speeds needed for robust survivability in high power electromagnetic fields. - Finalize and exploit studies of plasma in extreme environments (radiation and temperature) to demonstrate robust electronics capable of surviving in harsh environments orders of magnitude longer than current state of art silicon CMOS. - Complete device modeling based on characterization of fabricated microscale plasma devices and provide results to circuit and microsystem integrators for use in DoD system designs. - Transition of fundamental research findings into improved modeling simulation and design tool capabilities, enabling DoD relevant applications that require survivability in extreme radiation and temperature environments.			
Title: Semiconductor Technology Advanced Research Network (STARNet)* ***Description:*** * Formerly titled the Microsystems Research Consortium The Semiconductor Technology Advanced Research Network (STARNet) program is a new government-industry partnership focused on removing the roadblocks to achieving performance needed for future sensing, communication, computing, and memory applications. It combines the expertise and resources from select defense, semiconductor, and information companies with those of DARPA to sponsor an academic base focused on specific technology requirements set by experts in industry and DARPA. The program will involve close collaboration between these experts and the academic base with industry providing 60% of program funding matched by 40% from DARPA. For industry, leveraging funding and expertise with both other companies and DARPA to solve common technical hurdles in a pre-competitive research model is highly attractive. From the government perspective this kind of model also provides unique insight into the directions future commercial off-the-shelf (COTS) technologies will be taking. This perspective assists DARPA in defining the technology gaps where the DoD can make the most out of its limited resources by investing in those areas where the largest technology discrimination can be achieved. This discrimination is key to expanding technological superiority of the United States DoD.	0.000	22.740	20.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
Research in STARNet is divided into a discovery thrust (ACCEL) and an integration thrust (NEXT) focused on combining current or emerging technologies to provide new capabilities. ACCEL includes projects governed by virtual academic centers discovering new material systems, devices, and novel computing/sensing architectures. NEXT involves projects on advanced analog and mixed signal, complex system design tools, and alternative computing architectures. As the projects in ACCEL mature it is expected that they will replace the complementary metal-oxide semiconductor (CMOS) based efforts currently in NEXT. The STARNet program is unique. It creates a community where industry and government participate as co-sponsors to guide and learn from a large academic research base, with DoD shaping the goals to have direct impact on important long-range DoD problems. STARNet has a 5-year duration. It is expected that industry and DARPA will continuously evaluate STARNet and their respective challenges to determine if another collaborative program is warranted at the conclusion of the 5-year term. ***FY 2013 Plans:*** - Initiate the following university-based Centers: ACCEL Thrust Function Accelerated nano-Material Engineering (FAME) focusing on nonconventional material systems and devices incorporating nanostructures with quantum-level properties to enable analog, logic, and memory devices beyond binary computation. ACCEL Thrust Center for Low Energy Systems Technology (LEAST) will focus on achieving low power electronics through combining nonconventional material systems and quantum-engineered devices into novel integrated circuits and computing architectures incorporating the developed capabilities. ACCEL Thrust Center for Spintronic Material, Interfaces, and Novel Architectures (C-SPIN) will focus on electron spin-based memory and computation to overcome the power, performance, and architectural constraints of conventional devices. C-SPIN will focus on magnetic materials, spin transport, novel spin-transport materials, spintronic devices, circuits, and associated architectures. NEXT Thrust Systems On Nanoscale Information fabriCs Center (SONIC) focuses on shifting the model of computation from a deterministic digital foundation to a statistical one. The center will produce new strategies and designs optimized for applications where statistically accurate computations are sufficient, or even more adequate, thereby increasing energy efficiency. NEXT Thrust The Center for Future Architectures Research (C-FAR) will investigate highly parallel computing implemented in nonconventional computing systems. NEXT Thrust The TerraSwarm Research Center addresses the challenge of providing city-scale capabilities via the deployment of geographically distributed applications on a swarm of shared platforms. Two scenarios are of interest: a city during normal operation and a city during natural or man-made disasters (e.g., hurricanes, earthquakes, or terrorist attacks). ***FY 2014 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Continue joint government-industry support of the Centers established under the two thrusts (NEXT and ACCEL) and oversee efforts to allow for re-direction as needed. Monitor and assess progress towards technical goals proposed by Centers. Goals include: FAME: (1) Reduce power consumption of current spintronic devices by 100x to outperform scaled CMOS, (2) produce SRAM devices with 25x higher density and 100x lower off-state leakage, (3) demonstrate logic switches operating at 0.1 V with 100x-10,000x reduction in energy. LEAST: The primary metric of the various proposed innovative devices is improved subthreshold slope, the abruptness with which the device turns on. The challenge is to reduce it as far as possible below the theoretical CMOS limit of 60 millivolts/decade. Circuit power levels then scale down proportionally. C-SPIN: (1) Demonstrate 100x improvement in energy dissipation compared to CMOS, (2) show scalability to sub-10 nanometer dimensions, 3) investigate new capabilities such as nonvolatility and non-Boolean computing architectures. SONIC: (1) Investigate potential for 100x energy efficiency and 10,000x error robustness improvements by utilizing stochastic nature of novel nanoscale computing technologies, 2) seek 10x improvement in energy efficiency from innovative scaled digital-analog mixed signal circuits, 3) demonstrate 100x energy efficiency enhancement from neuro-inspired cognitive information processing systems. C-FAR: Investigate potential for 10-100x computational energy efficiency improvement utilizing innovative parallel architecture designs and memory bandwidth reduction with built-in fault tolerant mechanisms. TerraSwarm: Develop (1) smart city "cloud backbone" for global data analytics, access, and archiving, (2) mobile battery-powered personal devices, and (3) swarm devices to sense and actuate in the physical world.			
Title: Arrays at Commercial Timescales (ACT) ***Description:*** There is a critical shortage of digitally savvy Radio Frequency (RF) engineers who are capable of exploiting the latest in digital electronics technology and applying it to traditionally RF and analog applications such as phased arrays. This program will develop arrays that are heavily digitally influenced and that can be connected together as if they represented nodes on a traditional computing network. New advances in digital circuits at every element array panel will allow for ubiquitous phased array technology with heretofore unrealized coverage and capabilities. This program will take a fundamental look at the role of digital arrays and how commonality and aggregation can be affected by emerging capabilities. Simultaneously, this effort will focus on the development of arrays which can quickly create different unique RF personalities/capabilities on top of common digital hardware. The project will demonstrate levels of diversity in the use of the electromagnetic spectrum which is severely limited by the current approach of hand designing the array with heavily specialized RF beamformers that are unique to each system. This program also has related applied research efforts funded under PE 0602716E, Project ELT-01. ***FY 2014 Plans:***	0.000	0.000	9.876

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Develop array components that can demonstrate interoperability over a wired or wireless network such that the realized performance is an integrated sum of each individual array's performance. - Develop design techniques suited to common digital hardware components for phased array elements that can be seamlessly integrated into a wide range of platforms. - Develop electromagnetic interface elements capable of reconfiguring for various array use cases and operational specifications.			
Title: Micro-coolers for FPAs (MC-FPA) ***Description:*** The Micro-coolers for FPAs program will develop low size, weight, power, and cost (SWaP-C) cryogenic coolers for application in high performance infrared (IR) cameras. It is well known that the sensitivity of an IR focal-plane array (FPA) is improved by cooling its detectors to cryogenic temperatures. The disadvantages of state-of-the-art cryo-coolers are their large size, high power and high cost. Thermoelectric (TE) coolers are relatively small, but are very power hungry. To reduce IR camera SWaP-C, innovations in cooler technology are needed. This program will exploit the Joule-Thompson (J-T) cooling principle, in a silicon-based MEMS technology, for making IR FPA coolers with very low SWaP-C. MEMS microfluidics, piezoelectric MEMS, and complementary metal-oxide semiconductor (CMOS) electronics will be used to demonstrate an integrated cold head and compressor, all in a semiconductor chip. This program has related applied research efforts funded under PE 0602716E, Project ELT-01. ***FY 2014 Plans:*** - Design and demonstrate a chip-scale cold-head for 640 x 480 IRFPA chip with 4-6 um unit cell size for extended shortwave infrared (e-SWIR, 1-2.4um cutoff). - Design and test a five stage micro-cooler with an integrated piezoelectric compressor and cold-head with following metric: 30mm x 20mm x 10mm; 50 g. - Finalize design for operation down to 150K with 350mW heat lift.	0.000	0.000	1.500
Title: Optical Radiation Cooling and Heating in Integrated Devices (ORCHID) ***Description:*** Many Department of Defense (DoD) systems use micro- and nano-electromechanical systems (MEMS and NEMS). Such devices are used in compact accelerometers and gyroscopes for stability control in inertial navigation and in switches for optical communication and data routing. However, they 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. 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	4.300	4.950	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
envisioned that such devices, once demonstrated, will find broad application across DoD, particularly in the areas of force sensing and optical communication. ***FY 2012 Accomplishments:*** - Demonstrated an on-chip opto-mechanical oscillator with frequency greater than 5 gigahertz (GHz); and a phase noise of less than -111 decibels relative to the carrier per hertz (dBc)/Hz at 10 kilohertz (kHz), a performance compatible with modern communication and radar systems. - Demonstrated an integrated fiber-based Fabry-Perot resonator with a finesse of 100,000. This cavity was coupled to a silicon nitride membrane with a high mechanical quality factor and had a second order coupling strength of up to 20 GHz/nanometer (GHz/nm)^2. Such devices are ideal for squeezed light production in a small integrated device. - Demonstrated laser-cooling of a micro-mechanical system into its quantum mechanical ground state and measured quantum signatures of the mechanical motion. Such devices are useful for low-noise and high sensitivity force, mass and acceleration sensors. - Demonstrated a low phase noise stimulated-brillouin-scattering microwave oscillator in a high Q silica micro-disk resonator with a carrier frequency of 21.7 GHz. ***FY 2013 Plans:*** - Demonstrate broadband integrated optomechanical 10 GHz acousto-optic modulator/shifter with an efficiency >10% (room temperature, electronic drive, telecom wavelengths). - Demonstrate a fully micro-chip packaged (laser, detector, and transducer) optomechanical continuous position sensor with back-action-imprecision product within a factor of 2 of the Heisenberg limit. - Demonstrate quantum state transfer via optomechanical dark modes which are immune to thermal noise and thus, such devices would operate at room temperature. - Develop a hybrid optomechanical system consisting of a Silicon Nitride-nanobeam and a silica micro-sphere with an optomechanical coupling rate > 1 Megahertz (MHz). Such devices will be used for quantum state transfer at room temperature and wavelength conversion with a fidelity > 0.7. - Develop a fully packaged, amplifier-free, Aluminum Nitride (ALN) optomechanical microwave oscillator with a phase noise less than -120 dBc/Hz at 10 kHz offset with a 10 GHz carrier frequency. The final packaged device will include ALN optomechanical resonator, on-chip optical coupling and on-chip Germanium (Ge) photo-detectors.			
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, one such program was the Compound Semiconductor Materials On Silicon (COSMOS) program, in which transistors of Indium Phosphide (InP) could be freely mixed with silicon complementary metal-oxide semiconductor (CMOS) circuits to obtain the benefits of both technologies	3.500	9.113	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
(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. The Basic Research part of this program is focusing 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. This program has applied research efforts funded in PE 0602716E, Project ELT-01, and advanced technology development efforts funded in PE 0603739E, Project MT-15. ***FY 2012 Accomplishments:*** - Initiated development of new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices, in particular the demonstration of novel electronic-photonic integrated components and circuits. - Investigated theoretically, and via bench-top experiments, novel electronic-photonic heterogeneously integrated architectures for applications such as low-noise lasers, RF signal sources, and laser radar on a chip. - Initiated development of noise measurement methodology with sensitivity beyond state-of-the-art for advanced lasers and optoelectronic signal sources being developed within DAHI. ***FY 2013 Plans:*** - 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. - Initiate fabrication and test of heterogeneously integrated ultra-low-noise laser sources and on-chip laser radar systems. - Continue development of noise measurement methodology with sensitivity beyond state-of-the-art for advanced lasers and optoelectronic signal sources being developed within DAHI.			
Title: Focus Center Research Program (FCRP) ***Description:*** The Focus Center Research Program (FCRP) was 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. ***FY 2012 Accomplishments:***	16.578	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Achieved record high enhancement of thermal conductivity of thermal interface "grease" by 23 times using an advanced graphene polymer. Integrated circuit processor chip cooling capacity increased from 1-5 to 14 watts per milli-Kelvin (W/mK) to date, approaching the industry goal of 25-30 W/mK to cool future processors. - Achieved record 50% higher current in gallium nitride-based power transistor (AlGaN/GaN HEMT) for high electrical power required in applications from powering integrated circuits to automobiles to radar. - Demonstrated major achievement in improving practical carbon nanotube transistors by increasing their packing density by factor of seven, to 100 nanotubes per square micrometer. This produces one-half of the ultimately required current, a huge step toward practical implementation. - Demonstrated first silicon-compatible germanium quantum well waveguide modulator with 7 Gigabit (Gb)/s transfer data rate for photonic IC interconnects.			
Title: Quantum Entanglement Science and Technology (QuEST) ***Description:*** The Quantum Entanglement Science and Technology (QuEST) program has explored 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 has been 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 were addressed. 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 2012 Accomplishments:*** - Continued fundamental research in the area of quantum information. - Characterized and manipulated entangled quantum systems.	4.650	0.000	0.000
Accomplishments/Planned Programs Subtotals	36.528	50.103	46.876

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
MS-01: *MATERIALS SCIENCES*	-	100.165	86.540	82.819	-	82.819	75.186	73.824	84.877	90.263	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Nanoscale/Bio-inspired and MetaMaterials	9.439	12.380	12.205
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, including metamaterials, and materials exhibiting a permanent electric charge (charged matter). ***FY 2012 Accomplishments:*** - Applied selected fabrication techniques and produced materials with architectural features designed to exhibit predicted material properties, such as high strength at low density. - Initiated experimental characterization of effects of varying architectural features on targeted material properties. - Initiated sensitivity analyses to develop and validate optimization algorithms for material properties. - Initiated multidimensional architecture-to-property design space analysis for 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 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 research to determine extent to which properties normally coupled, can be decoupled using architecture-to-properties design methodology.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Initiate scalability research to determine degree to which fabrication methods are amenable to scaling and degree to which architectural control can be maintained. ***FY 2014 Plans:*** - Design materials with decoupled property combinations (e.g., strength/density, stiffness/thermal expansion) using architecture-to-property trade space capability. - Demonstrate fabrication methods amenable to scaling and that permit architectural control capable of maintaining decoupled properties. - Demonstrate targeted enhancement to material properties (e.g., strength of steel and density of water). - Establish manufacturability and amenability to scaleup. Provide fabrication and characterization data package.			
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, and enabling real-time detection as well as analysis of signals and molecules and origin of emergent behavior in correlated electron devices. Arrays of engineered nanoscale devices will result in an order of magnitude (10 to 100 times) reduction in the time required for analysis and identification of known and unknown (engineered) molecules. This program will develop novel nanomaterials for exquisitely precise purification of materials, enabling such diverse applications as oxygen generation and desalination, ultra-high sensitivity magnetic sensors, and correlated electron effects such as superconductivity. Additionally, 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. Finally, this program will develop stabilization and scale-up methods to fabricate high pressure crystal structures within domains not previously possible. This offers the promise to exploit the incredible properties of high pressure phases (e.g, hardness for armor) using economically viable manufacturing approaches. ***FY 2012 Accomplishments:*** - Verified the initial unified physical intelligence theory and justified its underlying assumptions in the context of model systems that support the emergence and evolution of novel structure. - Expanded the physical intelligence theoretical effort to include neuropercolation models and address correlated effects such as self-organized criticality, renormalization, scaling, and out-of-equilibrium physics. - Demonstrated the spontaneous, abiotic evolution and complex spatial and temporal organization in electro-physical systems in response to structure and resources from the environment. - Quantified the emergent hierarchical structures that evolve from the demonstrated electro-physical systems.	11.650	5.159	6.500

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated the ability to design an evolving electro- physical system and direct its evolution toward specified objectives in the form of a challenge problem or application. - Initiated development of computational tools to formulate processing pathways to stabilize and scale up high pressure crystal phases. - Established 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, high pressure phases of gaseous materials (extended solids) that have superior mechanical/functional properties. - Initiate development of synthesis techniques for producing extended solids at temperature and pressures amenable to scale up. ***FY 2014 Plans:*** - Validate computational tools against known high pressure materials and apply to develop multistep pathways to selected extended solids. - Apply synthesis techniques to, and initiate synthesis of, intermediates projected to lead to selected extended solids. - Develop and demonstrate methods to stabilize extended solids at ambient temperatures and pressures.			
Title: Atomic Scale Materials and Devices ***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). Novel material properties and device functionality obtained by designing and making atomically thin (i.e., two-dimensional) materials will also be pursued. ***FY 2012 Accomplishments:*** - Generated polar molecules and studied long-range character and ordering inside an optical trap. - Made detailed measurements of the thermodynamical and dynamical properties of systems near a quantum phase transition. - Realized synthetic spin-orbit coupling in atoms and measured its effects on band structure and transport (spin Hall effect). - Implemented an all-optical switch design based on optically-induced absorption compatible with a 50 nanometer range in input wavelength.	8.563	2.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Demonstrated total energy dissipation for an optical switch of less than 100 attojoules per operation with a simultaneous signal loss of less than 0.02 decibels. - Demonstrated Zeno-based switching at both cryogenic and room temperatures. - Initiated the design and fabrication 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 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. Finally, the program will develop approaches for optical frequency division and harmonic generation that will allow accurate optical clocks and table-top sources of coherent X-rays for medical and non-medical applications. ***FY 2012 Accomplishments:*** - Investigated the practical limits to the information content of a single photon via inclusion of various real-world imperfections. - Demonstrated the utility of information theoretic approach via highly photon-efficient communications. - Demonstrated the utility of information theoretic approach via improved low-light level imaging. - Demonstrated the benefit of orbital angular momentum for communications applications. - Evaluated the information capacity of candidate ghost imaging and laser radar systems. - Characterized surfaces of constant performance in the space of camera cost factors including optics, focal planes, and computation. - Developed a new method of optical metrology based on rotating point spread functions and computational imaging. - Studied the use of nanostructured optical surfaces for polarization control and spectral filtering. - Developed 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.	21.500	25.250	18.889

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate novel technologies for encoding and decoding orbital angular momentum. - Demonstrate low-light level imaging at an information rate of 5 bits per photon. - Construct a low phase noise microwave oscillator based on optical frequency division from a fiber based optical frequency comb. - Build a 4 micron, 1-10 Kilohertz (kHz) laser system with a pulse energy of 10 Megajoules (mJ). ***FY 2014 Plans:*** - Demonstrate a 10 Gigahertz (GHz) oscillator using optical frequency division with a micro-frequency comb. - Demonstrate free space time transfer over 10 km with timing error 1000 times better than GPS (< 10^-12 seconds timing error over 1 second). - Demonstrate laser pulses < 50 attaseconds for stroboscopic imaging of material dynamics.			
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. It will also exploit novel optical nonlinearities that can be used to combine quantum systems with classical coherent pulses to enable secure quantum communications over conventional fiber at rates compatible with commercial telecommunications. 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 2012 Accomplishments:*** - Demonstrated an optomechanical accelerometer with sensitivity of (>10^-7 of the acceleration due to gravity [micro-g] per root hertz) and bandwidth (>10 kilohertz [kHZ]) compatible with inertial navigation of unmanned aerial vehicles. - Demonstrated a diamond magnetometer with < 5 microtesla/hertz^1/2 and < 10 nanometer (nm) resolution. - Demonstrated a compact cold alkaline beam source and optical reference cavity for an optical clock. - Investigated the feasibility of high average power, ultrafast laser architectures suitable for efficient high harmonic generation and 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. - Demonstrate a compact optical clock. - Demonstrate on-chip, octave-spanning frequency comb with < 200 Gigahertz (GHz) line spacing.	10.674	18.591	23.352

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate proof-of-principle of novel technology capable of decoupling transmission loss from secure-bit-rates in quantum communications systems. - Design prototype macroscopic quantum communications system that has the potential to scale to 1 - 10 gigabit per second secure communications rates and 1,000 - 10,000 kilometer secure communications distances. - Determine requirements for large-scale testbed of macroscopic quantum communications technologies capable of simulating realistic conditions for 10 gigabit per second secure communications over 1,000 - 10,000 kilometers. ***FY 2014 Plans:*** - Demonstrate an optomechanical accelerometer with sensitivity (>100 10^-9 acceleration due to gravity/Hz^1/2) and bandwidth (>10 kHz) compatible with inertial navigation of unmanned aerial vehicles. - Demonstrate a single diamond nitrogen vacancy magnetometer with < 10 nm resolution that is compatible with imaging biological systems. - Validate the performance of a compact (< 10 liters) portable optical clock with a timing accuracy 10 times better than satellite GPS clocks. - Demonstrate prototype macroscopic quantum communications systems at secure long haul communications distances. - Demonstrate improved decoupling between secure bit rate and loss in long-haul quantum communications. - Implement macroscopic quantum communications testbed capable of simulating realistic conditions (loss, noise, and decoherence) through the modern fiber-optic telecommunications grid.			
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. 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 efforts 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 2012 Accomplishments:*** - Characterized conditions surrounding artificial duct creation and conducted experiments to determine mechanisms by which VLF waves can be injected into these ionospheric ducts. - Conducted a series of experiments to quantify ionospheric D-region absorption, F-region irregularities, spatial distribution of ELF/VLF source currents, and Electrojet electric fields.	12.517	9.991	8.873

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Conducted 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. - Conducted 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. - Conducted 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, visible and near-infrared (IR)/short wave IR, 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 compact intracloud discharges on lightning propagation as well as their potential contribution to the production of very large blue jets. ***FY 2014 Plans:*** - Experimentally define and quantify the causative mechanisms behind lightning initiation, propagation and attachment. - Experimentally (in-situ) measure dosage of radiation emitted during the lightning process and its potential impact on aircraft and humans. - Experimentally define and quantify all ionospheric effects associated with terrestrial lightning. - Test active control of ionospheric geomagnetic substorm evolution process. - Test innovative techniques to suppress auroral clutter, which inhibits the effective use of over-the-horizon radar. - Induce triggered emissions (VLF amplification) to precipitate electrons by injecting artificial VLF waves (radiation belt remediation).			
Title: MesoDynamical Architectures (Meso) ***Description:*** The Mesodynamic Architectures (Meso) program is exploiting recently discovered physics present at small scales to demonstrate transformative technologies and redefine the building blocks of modern communication, sensing, and computing technologies. The program is divided into four thrusts; dynamics of nonlinearity and noise; coherent collective dynamics;	25.822	13.169	13.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014

information transduction; and coherent feedback control. In each of these thrusts performers are focused on demonstrating specific technologies that will have significant impact on DoD capabilities. Technologies include transistors operating at 100x lower power than the commercial semiconductors that will provide the DoD with unique computing capabilities.

FY 2012 Accomplishments:
Nonlinearity and Noise Thrust:
- Produced the first ever Micro-Electro-Mechanical Systems (MEMS) device capable of navigation by using Meso program prototypes to acquire and track GPS.
- Demonstrated the core concept of using nonlinearity to improve oscillator fidelity in 3 different architectures.
- Achieved lower phase noise, a key performance metric associated with carrier frequency, which is desired to be increased into the range of 1 Gigahertz (GHz) where there is lack of options for communication applications.
- Demonstrated the Phase 1 temperature stability metric of 30 parts-per-million over -40 to 85 degrees C, a temperature range common to military electronics and included in several military specification documents (MilSpecs).
- Exceeded the acceleration stability metric of 10-5 g-1 by a factor of nearly 100,000 by demonstrating stabilities of 3x10-10 g-1. This result opens the door to navigation of a number of military applications where high vibrations are the limitation.
- Performed a second demonstration of oscillator performance in communications radios that increased their range by more than 200 kilometers (km).

Coherent Collective Dynamics (Topological Insulator) Thrust:
- Demonstrated increased understanding of the topological insulator properties, a new state of matter.
- Reduced bulk impurities by more than 100x, resulting in a >10x improvement of the surface to bulk carrier ratio.
- Achieved a key step in realizing both a new transistor concept and a novel programmable interconnect by using a magnetic field to open a gap in topologically insulating surface states.
- Demonstrated the first topological insulator Field Effect Transistor and the first topological insulator transistor operated by magnetic switching.
- Demonstrated utilizing Topological Insulators for a Thermoelectric device. The device will potentially provide 10 to 1,000 times better effective cooling of electronics than state-of-art.

Information Transduction Thrust:
- Discovered new mechanism to differentiate and sense biomolecules; developed efficient new method of filtering biomolecules from fluids in a single step; and built reference database for the first biomolecules. These discoveries are key enablers for realizing a portable biomolecule detector by allowing electronic discrimination of biomolecules efficiently, with low noise for high accuracy, and high throughput required in DoD application.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated radically enhanced and broadband light-matter interactions (3,000 times stronger coupling between light and mW optical power) and engineered material dispersion for tailorable phonon emission. This physics will be developed into the first practical solid-state phonon laser, which will enable the realization of a low phase noise, chip-scale oscillator. Notable qualities of the oscillator include its potential stability in extreme environments, on-chips nature and complementary metal oxide semiconductor (CMOS) compatibility. - Built and tested prototype for the first widely tunable delay line oscillator for broadband signal processing. Coherent Feedback Control Thrust: - Established the building blocks for the construction of a phonon laser to enable the development of tunable on-chip filters, data encoding and novel oscillators with improved performance and/or new capabilities. - Developed quantum hardware description language to be used in the creation of a computational simulation engine for nanophotonic circuits stabilized via coherent quantum feedback. - Demonstrated physics effects in atomic systems to be used in the design of nanophotonic circuits with multiple components, attojoules switching energy and nanoseconds switching time. ***FY 2013 Plans:*** Nonlinearity and Noise Thrust: - Achieve key Phase 2 metrics of phase noise better than -110 decibels referenced to the carrier (dBc)/Hz @ 1 Kilohertz (KHz) offset with a carrier frequency of 800 Megaherz (MHz) and temperature stability of 10 ppm from -40 to 85 degrees C. - Determine boundaries to continued improvement of acceleration stability. - Experimental investigation of vibration stability. Demonstrate new radar capabilities in a high vibration environment (e.g., track slow moving objects from helicopters, maintain GPS lock in a projectile as it is fired). 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 prototype structures using information transduction to demonstrate advanced communication, computing and sensing technologies with new functionalities, higher bandwidth, and reduced noise and operating power, amenable to environments with limited resources. - Demonstrate prototype for the electronic biomolecular sensor, reducing noise and current required for operation, and increasing its detection capacity and resolution. Detect first model macro-molecule and its mutations.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Coherent Feedback Control Thrust: - Increase the number of devices per optimization handled by the computational simulation engine. - Fabricate nanophotonic circuits with multiple components, 10 femtojoule switching energy, 10 nanoseconds (ns) switching time, and 2x error suppression via coherent feedback control. ***FY 2014 Plans:*** Nonlinearity and Noise Thrust: - Build on the achievements of Phase 1 and Phase 2 by combining improvements into one device exceeding all the Phase 3 metrics: phase noise below -120 dB/Hz @ 1 kHz offset with a 1 GHz carrier. - Reduce device size to less than 1 mm^3, demonstrate temperature stability to better than 3 parts per million (ppm) over -45 to 80 degrees C, and show acceleration stability to better than 10^-8 g^-1. - Transition to applications such as radar for slow moving targets, munitions tracking, hiding and detecting signals in noise, and increasing communications range. Coherent Collective Dynamics (Topological Insulators) Thrust: - Demonstrate magnetically gated, ultra-low power (0.1V), ultra-high switching speed (1 ns) topological insulator transistor. - Demonstrate ultra-low dissipation (4 times less than copper at 10 micrometers [µm]), programmable interconnects for electronic components. The interconnect resistance will be independent of its length, decreasing dissipation over long distances. - Demonstrate thermal interconnects with more than 10 to 1,000 times improvement in performance over state of the art. Information Transduction Thrust: - Improve designs to produce the next generation of energy-efficient prototype structures with enhanced performance and functionality for advanced communications, computing and sensing technologies. - Optimize the biomolecular sensor prototype by further reducing noise, power dissipation and operation current, increasing packaging density, and improving filtration throughput and detection capability. Detect various analytes together. Coherence Feedback Control Thrust: - Refine computational simulation engine, maximize number of devices per optimization and circuit error suppression via coherent feedback, in preparation for release of software for public distribution. - Increase number of components in nanophotonic circuits, reduce switching energy and time, improve circuit robustness and error suppression via coherent feedback.			
Accomplishments/Planned Programs Subtotals	100.165	86.540	82.819

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C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
TRS-01: *TRANSFORMATIVE SCIENCES*	-	41.809	35.250	50.161	-	50.161	55.227	54.361	68.900	66.453	Continuing	Continuing

[#] FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

[##] The FY 2014 OCO Request will be submitted at a later date

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.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2012	FY 2013	FY 2014
Title: Social Media in Strategic Communication (SMISC)	10.702	14.720	20.161

Description: 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 threaten national security and has 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 2012 Accomplishments:
- Developed formal representations of microblog content by modifying topic modeling techniques such as latent semantic indexing and latent dirichlet allocation to work on streaming data.
- Applied and adapted leading-edge natural language processing techniques to social media where highly contracted forms of communication are common.
- Developed big graph models and advanced analytics for social dynamics in social media.
- Developed algorithms for detecting, classifying, measuring, and tracking the formation, development, and spread of ideas and concepts (memes) in social media.

FY 2013 Plans:
- Refine topic modeling techniques to accurately represent tactically significant content.
- Refine specialized algorithms to recognize purposeful or deceptive messaging and misinformation, persuasion campaigns, and influence operations across social media.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate models of influence operations using techniques of semi-automated narrative creation based on predictive social dynamics models. ***FY 2014 Plans:*** - Integrate algorithms for meme detection and tracking with algorithms for detecting deception, persuasion, and influence operations. - Develop high fidelity diffusion models for messages, narratives, and information across social media. - Combine integrated algorithms with diffusion models to create predictive simulations for the spread of given messages, narratives, and information.			
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. With its ability to perform complex chemistries, be flexibly programmed through DNA code, scale, adapt to changing environments and self-repair, biology represents one of the most powerful manufacturing platforms known. However, the DoD's ability to harness this platform is rudimentary. Living Foundries seeks to develop the 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 program will enable the rapid and scalable development of previously unattainable technologies and products (i.e. those that cannot be accessed using known, synthetic mechanisms) leveraging biology to solve challenges associated with production of new materials (e.g. flouropolymers, enzymes, lubricants, coatings and materials for harsh environments), novel functions (e.g. self-repairing and self-regenerating systems), biological reporting systems, and therapeutics to facilitate new solutions and enhancements to military needs and capabilities. 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 supply chains that are vulnerable to political change, targeted attack, or environmental accident. If successful, Living Foundries will do for biology what very-large-scale integration (VLSI) did for the semiconductor device industry: 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, develops and yields design rules and tools, and manages biological complexity through simplification, abstraction, and standardization of both processes and components. The result will be rapid design, construction, implementation and testing 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 the extensive cost and time it takes to engineer new systems and expanding the complexity and accuracy of	16.453	10.530	10.500

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
designs that can be built. Specific tools and capabilities include: interoperable tools for design and modeling; automated, modular and standardized fabrication and genome-scale engineering processes; 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 begins in FY 2013 in PE 0602715E, project MBT-02. ***FY 2012 Accomplishments:*** - Initiated development of high-level design, automation and construction tools to increase the efficiency, sophistication, and scale of possible designs. - Initiated design and development of modular regulatory elements, parts, and devices necessary to build hierarchical, complex genetic networks and enable rapid production of materials. - Initiated development of orthogonal parts, devices circuits and systems (including successful demonstration of a recoded, orthogonal system) in order to mitigate system cross-talk. - Initiated investigation, design, and development of standard test platforms and chassis for predictable design and testing of bioproduction pathways. - Initiated and successfully demonstrated 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 quantitative modeling studies to predict platform behavior. - Continue development of increasingly sophisticated automation of design, construction, and quality control (QC) tools to improve the efficiency, sophistication, and scale of possible designs and production pathways. - Continue development of device and circuit designs and topologies that are orthogonal to and portable across multiple host chassis and whose behavior can be predicted a priori while producing minimal cross-talk. - Begin designing, constructing, modeling, and testing large scale, hierarchical genetic networks to demonstrate ability to forward engineer bioproduction pathways and functions. - Begin to research and develop real-time feedback and control mechanisms and tools for more complex and robust experimental design and control of engineered circuits and networks. - Continue research, development, and testing of new characterization and debugging tools for synthetic regulatory networks. - Begin initial experiments to design and test new production pathways for novel materials. ***FY 2014 Plans:*** - Begin research and development on incorporation of new, non-natural components into bio-manufactured materials (including non-natural amino acids and an expanded set of atomic elements) to broaden the set of new materials and functions.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Begin initial demonstration of automated, software-controlled, genome-scale cellular engineering process platforms that simultaneously increase the scale and complexity of experimentation and decrease the cost and time to engineer a new production system. - Continue research and development of tools and methodologies to program, reprogram, and enable spatio-temporal control and feedback for engineered systems. - Continue to design and test production pathways for novel materials. - Develop novel algorithms and software that links the design of genetic systems to their assembly and characterization data to begin integrating the design of systems with their construction and ultimate testing/debugging. - Begin development and demonstration of tools to enable engineering of currently intractable chassis for novel and enhanced functionalities and materials production.			
Title: Open Manufacturing ***Description:*** 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. The applied research component of this program is funded in Program Element 0602715E, Project MBT-01 under Materials Processing and Manufacturing. ***FY 2012 Accomplishments:*** - Identified experiments and targeted tests that rapidly optimize part qualification processes. - Developed simulation tools that allow rapid predictions of guaranteed performance in actual manufactured products. - Developed new manufacturing/fabrication capabilities that allow for low-volume production runs with the same economies as high-volume ones. - Initiated process and process models that enable rapid setup and processing thereby reducing entry costs and timelines. - Established manufacturing demonstration centers of expertise 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. - 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 methods for testing and qualification of new manufacturing technologies using impartial manufacturing centers of expertise.	12.000	10.000	11.500

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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 2012	FY 2013	FY 2014
- Perform virtual manufacturing system exercises that pass design, manufacture, and verification of a specific part through the entire chain. ***FY 2014 Plans:*** - Develop a fundamental understanding of the impact on quality features and parameters to establish process windows for new rapid process technologies. - Develop methods to enable design of tests and inspections that incorporate material condition, design vulnerabilities, process variability, as well as incorporating test variability and statistical treatments. - Develop basic architecture and statistical environment to enable rapid qualification and certification approaches through the interaction and use of probabilistic models for process, design, and materials.			
Title: Networked Approaches to Intractability ***Description:*** The Networked Approaches to Intractability program will tackle complex problems such as corruption, human trafficking, and genocide that appear intractable. The U.S. military is increasingly involved with societies plagued by such seemingly self-perpetuating evils. Problems in this class often include social, cultural, ideological, political, and economic constraints, and consequently stakeholders with radically differing world views and frames of reference. Limited U.S. patience for long-term engagements and interconnectedness with other similarly complex problems further characterize the challenge. Social networking has shown initial promise for problems of this nature, such as bribery, though on a smaller scale. The Networked Approaches to Intractability program will develop social networking-based applications that incorporate recent breakthroughs in game theory and multi-party negotiation to break vicious social cycles and create virtuous social cycles. The program seeks approaches to modeling and reasoning about problems of this nature, incentive mechanisms to elicit relevant information from stakeholders, and the creation of tools for combatant commanders and stakeholders collaboratively addressing such challenges. ***FY 2014 Plans:*** - Research the design of social networking-based applications to address seemingly intractable "super wicked" problems such as corruption, human trafficking, and genocide. - Develop plans for demonstrating these applications in military stability, security, transition, and reconstruction operations. - Coordinate with PACOM to apply techniques relevant to their theater of operations.	0.000	0.000	4.500
Title: Vanishing Programmable Resources (VAPR) ***Description:*** The Vanishing Programmable Resources (VAPR) program will create electronic systems capable of physically disappearing (either in whole or in part) in a controlled, triggerable manner. VAPR will enable a host of previously unrealizable technologies that can be programmed to disappear, are biocompatible, and/or are physically reconfigurable. Applications include sensors for conventional indoor/outdoor environments (buildings, transportation, and materiel), environmental monitoring over large areas, and simplified diagnosis, treatment, and health monitoring in the field. The program will develop and establish an	0.000	0.000	3.500

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
initial set of materials and components along with integration and manufacturing capabilities to undergird a fundamentally new class of electronics defined by their performance and transience. These transient electronics ideally should perform in a manner comparable to Commercial Off-The-Shelf (COTS) systems, but with limited device persistence that can be programmed, adjusted in real-time, triggered, and/or sensitive to the environment. VAPR will build an initial capability to make transient electronics a deployable technology for the DoD and Nation. Applied research for the VAPR program is being performed in PE 0602716E, Project ELT-01. A basis set of transient materials and electronic components with sufficient electronic and transience performance is needed to realize transient electronic systems for environmental sensing and biomedical applications. Research and development of novel materials for implementing basic transient electronic components (i.e. actives and passives), power supply strategies, substrates and encapsulates as well as development of modes and triggers for transience will form the core of fundamental research activities. Transient components and devices developed in this technical area will form the basis for advanced functional circuit blocks and test systems to be developed in PE 0602716E, Project ELT-01. ***FY 2014 Plans:*** - Begin development of electronic materials that exhibit a useful combination of transience and the necessary physical characteristics required for sufficient electronic performance. - Begin development of materials and mechanisms for control of transience effects. - Begin development of device modeling tools that incorporate transience effects.			
Title: Cognitive Cloud ***Description:*** The Cognitive Cloud program used 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. ***FY 2012 Accomplishments:*** - Developed techniques for generating realistic synthetic social network data using cognitive models of crowd behavior and performed initial data analysis and validation studies.	2.654	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
- Held the Shredder Challenge to demonstrate the potential inherent to crowd-sourced approaches to military software development.			
Accomplishments/Planned Programs Subtotals	41.809	35.250	50.161

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	44.445	39.676	49.500	-	49.500	51.500	53.500	53.500	53.500	Continuing	Continuing
MED-01: *BASIC OPERATIONAL MEDICAL SCIENCE*	-	44.445	39.676	49.500	-	49.500	51.500	53.500	53.500	53.500	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	37.870	39.676	45.500	-	45.500
Current President's Budget	44.445	39.676	49.500	-	49.500
Total Adjustments	6.575	0.000	4.000	-	4.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	7.574	0.000			
• SBIR/STTR Transfer	-0.999	0.000			
• TotalOtherAdjustments	-	-	4.000	-	4.000

Change Summary Explanation

FY 2012: Increase reflects an internal below threshold reprogramming offset by the SBIR/STTR transfer.

FY 2014: Increase reflects increased activities in the Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) program.

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
Title: Human Assisted Neural Devices	19.934	10.176	9.000

Description: 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. A key aspect of this effort will be to develop non-invasive bioimaging techniques that are capable of rapid analysis and interpretation of brain tissue alterations including new methods of analysis and interpretation for measuring brain tissue alterations at the cellular scale.

FY 2012 Accomplishments:
- Assessed consistency of encoding long-term memory through use of patterned neural stimulation in pre-clinical models.
- Identified homogeneity of neural codes involving long-term memory in preclinical studies conducting various long-term memory tasks.
- Continued development of wireless neural interface for online, closed loop recovery of long-term memory encoding and retrieval in pre-clinical studies.
- Demonstrated that networks of neurons can be differentially modulated through optogenetic neural stimulation in in animal models.
- Used neuroimaging methods to model connectivity among different areas of the brain.
- Evaluated the ability to model multi-scale brain recording and imaging data in order to accurately predict underlying spiking behavior of groups of neurons.
- Investigated the ability in animal models to engage in virtual sensorimotor tasks through the use of recorded neural signals.
- Demonstrated ability of non-human primates to 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 the ability of non-human primates to perform a dexterous sensorimotor task using only auxiliary sensory information provided through a neural interface.

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- 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. ***FY 2014 Plans:*** - 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. - Develop new methods of analysis and interpretation for measuring brain tissue alterations without the need for image reconstruction. - Develop novel technologies, such as optical/non-optical tools and cellular dyes, to detect the functional dynamics of a cell or a group of cells in the tissues and organs of a living organism in a non-invasive manner. - Develop methods of data analysis and interpretation that will allow the mathematical characterization of normal and abnormal cellular processes in situ.			
Title: Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) ***Description:*** 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 capabilities, which are currently available only in centralized laboratories in the U.S., to 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 develop techniques that will enable the rapid establishment of transient immunity through stimulation of the production of components of the immune system to impart effective but temporary protection. This transient immunity would bridge the time gap between the delivery of a vaccine and the development of a long term protective immune response. Applied research efforts are budgeted in PE 0602115E, Project BT-01. ***FY 2012 Accomplishments:*** - Initiated development of modular and orthogonal nucleic acid-based elements for application within a sense-and-respond circuit operating within the context of a mammalian cell. - Investigated controlled expression in mammalian cells of synthetic circuit that responds to physiological biomarkers associated with health status. - Developed novel concepts and molecular approaches to enable deployable diagnostics.	19.511	24.500	40.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Developed novel reagents and materials for stabilizing self-collected biospecimens at room temperature for simple shipment and storage. - Developed methods for sample preparation that require no operator manipulation and are consistent with point-of-need and point-of-care settings. - Developed new methods for signal amplification amenable to deployable diagnostics. - Investigated the ability of administered synthetic oligonucleotides to direct cells to produce elements of the immune response. ***FY 2013 Plans:*** - Demonstrate development of modular and orthogonal nucleic acid-based elements for application within a sense-and-respond circuit that operates within the context of a mammalian cell. - Demonstrate controlled expression in mammalian cells of synthetic circuit that responds to physiological biomarkers associated with health status. - Quantify sensitivity and specificity of developed molecular approaches designed for deployable diagnostics using physiological concentrations of clinically relevant analytes in complex biospecimens. - Quantify performance of biostabilization reagents/materials to evaluate analytical recovery of clinically relevant molecules as compared to traditional stabilization methods that require cold-chain storage. - Quantify performance of methods for room temperature analyses and reagent stabilization to demonstrate analytical results with similar-to-enhanced performance as compared to current laboratory methods for clinical diagnostics. - Quantify detection limits achieved with signal amplification methods to demonstrate performance superior to current state of the art methods for quantification of low abundance biomarkers in an actionable timeframe. - Demonstrate performance of new sample preparation methods suitable for simple and multiplexed analysis 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. - Quantify the level of antibody and immunoadhesin production directed by the administration of synthetic oligonucleotides in comparison to standard vaccine delivery. - Investigate the impact of the antibody sequence on the therapeutic strength of immune response in vivo. ***FY 2014 Plans:*** - Demonstrate in mammalian cells the function of a synthetic circuit that can integrate multiple signals associated with health status and respond with a targeted change in cell function. - Demonstrate the ability to generate synthetic nucleic acid and protein circuit components that respond to an exogenously supplied small molecule drug trigger. - Demonstrate in mammalian cells the function of an orthogonal, multi-functional nucleic acid-based circuit with sense-and-respond functionality that responds to biomarkers of cell state. - Refine developed molecular approaches and develop targeted molecular assays designed for deployable diagnostics.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
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 2012	FY 2013	FY 2014
- Demonstrate biostabilization reagents/materials with numerous biospecimen types and processing/fluidic approaches to be eventually integrated into disposable and on-person diagnostic devices. - Demonstrate methods for room temperature analyses and reagent stabilization with numerous biospecimen types and fluidic approaches to permit collection and transport of patient samples for diagnostic analysis. - Demonstrate signal amplification methods in conjunction with processing/assay methods. - Demonstrate developed sample preparation methods in conjunction with simple and multiplexed analysis of biospecimens representative of those either self-collected under low-resource settings or collected by trained professionals at the physician-office settings to assist the diagnosis of an individual. - Demonstrate delivery of synthetic oligonucleotide constructs to cells appropriate to produce an antibody response. - Demonstrate antibody and immunoadhesin production targeted to specific disease classes. - Optimize antibody sequence for maximal therapeutic strength of immune response in vivo.			
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 Accomplishments:*** - Achieved detection over 10 days of ricin toxin B chain in whole blood using a surface enhanced Raman spectroscopy (SERS) substrate functionalized with degradation-resistant aptamers. - Flowed whole blood at 3 L/hr for 60 minutes without clotting in specially functionalized medical tubing. - Removed > 80% of pathogens and inflammatory molecules from flowing blood using label-free separation technologies. - Improved the outcome of 7x more virtual patients as compared to static treatment using a 4-state predictive control model. ***FY 2013 Plans:***	5.000	5.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Improve sensing technologies to achieve 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 data from small animal testing within the program.			
Accomplishments/Planned Programs Subtotals	44.445	39.676	49.500

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013[#]	FY 2014 Base	FY 2014 OCO [##]	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	95.661	110.900	114.790	-	114.790	123.742	129.603	133.309	133.000	Continuing	Continuing
BT-01: *BIOMEDICAL TECHNOLOGY*	-	95.661	110.900	114.790	-	114.790	123.742	129.603	133.309	133.000	Continuing	Continuing

[#] FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

[##] The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

This Program Element is budgeted in the applied research budget activity because it focuses 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
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B. Program Change Summary ($ in Millions)	FY 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	95.000	110.900	97.069	-	97.069
Current President's Budget	95.661	110.900	114.790	-	114.790
Total Adjustments	0.661	0.000	17.721	-	17.721
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	3.250	0.000			
• SBIR/STTR Transfer	-2.589	0.000			
• TotalOtherAdjustments	-	-	17.721	-	17.721

Change Summary Explanation

FY 2012: Increase reflects an internal below threshold reprogramming offset by the SBIR/STTR transfer.
FY 2014: Increase reflects planned expansion of the Dialysis-like Therapeutics and ADEPT programs.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Pathogen Defeat	19.000	15.000	14.617
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 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. ***FY 2012 Accomplishments:*** - Developed platforms to investigate evolutionary pathways of a virus under selective pressures. - Developed algorithms to predict effects of selective pressures on viral evolutionary pathways. - Used algorithm to investigate virus mitigation and frequency globally to predict the timing and geographic location of reassortment events. - Modeled processes to accurately predict the drift and shift of virus in pre-human, animal reservoirs. - Began development of a system for anticipating evolution of clinical drug resistance through the use of an in vitro viral-cell bioreactor. - Demonstrated novel sequencing technologies that reduce the error rate. - Demonstrated viral replication in cells encapsulated in microdroplets in a cell-viral infection system. ***FY 2013 Plans:***			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Develop a platform to reproducibly demonstrate the evolutionary pathway of a virus under multiple selective pressures. - Validate algorithms' abilities to predict viral evolution in the presence of one or multiple pressures. - Predict timing, location(s) and nature of genetic mutation(s) responsible for antiviral failure in an infected viral host (animal) model. - Predict number of viral generations necessary for the acquisition of antiviral resistance in an infected viral host (animal) model. - Predict location of genetic mutation(s) responsible for failure of a monoclonal antibody to neutralize a virus. - 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, and to predict emergence of dengue virus mutations in a region where dengue has recently appeared. - Demonstrate that the in vitro evolution platform accelerates evolution of drug resistance or immune escape. ***FY 2014 Plans:*** - Demonstrate that the in vitro bioreactor can be used to predict alteration in cell tropism or host range. - Validate viral evolution platforms and predictive platforms with a live fire test. - Transition predictive algorithms and in vitro evolution platforms to the Center for Disease Control (CDC) and other interested government agencies to increase preparedness for seasonal influenza as well as other emerging pathogens. - Transition predictive algorithms and in vitro evolution platforms to the pharmaceutical industry for prediction of emergence of drug-resistant strains of commercially relevant viruses.			
Title: Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT) ***Description:*** 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 Accomplishments:*** - Increased stability of RNA-based vaccines. - Demonstrated efficacy of RNA-based vaccines in a small animal model. - Demonstrated sample preparation methods designed for integration in disposable diagnostics that can be carried on-person, or in reusable diagnostics that can be used at the point-of-care.	11.169	15.000	29.852

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Developed high sensitivity colorimetric and electrical detection approaches of advanced instrumentation approaches for autonomous diagnostics that will be deployed as either on-person devices, or used at the point-of-care. ***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 device components (sample preparation/reagent delivery/detection components) to enable diagnostic device capabilities in the remote-clinic and low resourced settings. ***FY 2014 Plans:*** - Demonstrate quantitative performance metrics for integrated components developed to demonstrate capability toward a complete diagnostic device prototype. - Demonstrate ability to manipulate type of immune response induced by RNA-based vaccines. - Demonstrate ability to target delivery of RNA-based vaccines to specific cell types. - Develop novel methodologies to deliver nucleic acid constructs encoding one or hundreds of antibodies identified from immunized or convalescent patients. - Demonstrate immediate broad spectrum transient immune prophylaxis in host via delivery of nucleic acids that transiently produce multiple antibodies.			
Title: Tactical Biomedical Technologies ***Description:*** 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. Another effort will develop assessment tools to identify soldiers in real time who represent depression and suicide risk by identifying speech biomarkers. 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 Accomplishments:*** - Demonstrated hemostasis agent stability consistent with operational requirements.	18.223	15.500	13.321

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
- Demonstrated hemostasis in less than four minutes on a non-compressible injury model. - Demonstrated that hemostatic material does not induce intracavitary fibrosis within 28 days when left at the wound site. - Designed scale-up for large-volume hemostasis agent synthesis. - Initiated discussions for wound stasis system FDA approval. - On laboratory scale, completely synthesized the following active pharmaceutical ingredients (APIs) in continuous flow: Diphenhydramine, Diazepam, Ibuprofen, and Lidocaine. - On laboratory scale, developed crystallization process for seven APIs (Diphenhydramine, Diazepam, Ibuprofen, Lidocaine, Atropine, Fluoxetine, and Doxycycline), and liquid formulations for six and injection/tablet formulation for the seventh API (Atropine). - Designed and developed benchtop modular reactor and spiral reactor. - Conducted mixing and heat transfer simulations for modular reactor design and heat transfer simulations for spiral reactor design. - Developed integrated liquid-liquid separation technique using porous diaphragm membrane as feedback-based back pressure regulator. - Modeled end-to-end process (continuous flow chemistry and downstream processing) for Lidocaine and Diazepam. - Developed methods to improve efficiency of transcranial photon energy deposition. ***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. - Assess manufacturing costs and processes required for pilot-scale production. - On laboratory scale, synthesize in continuous flow all seven APIs. - Demonstrate continuous flow synthesis of all seven APIs using integrated manufacturing platform. - Design and test drug product crystallization and formulation for the seven APIs in integrated manufacturing platform. - Engage the FDA for input on process analytical technologies (PAT) and current good manufacturing practice (cGMP) for the seven APIs. - Develop breadboard prototype device for treatment of intracranial hemorrhage using laser energy through the skull and tissues. - In vivo demonstration of transcranial photocoagulation of intracranial vessels. - In vivo demonstration of photo-induced vasospasm in intracranial vessels. - 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. ***FY 2014 Plans:***			

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- On laboratory scale, demonstrate continuous flow synthesis of an additional seven APIs (Diethylcarbamazine, Ciprofloxacin, Azithromycin, Benzylbenzoate, Methylrosanilium chloride, Ipratropium, and Neostigmine). - Demonstrate continuous flow synthesis of additional seven APIs in handheld manufacturing platform. - Engage the FDA for input on PAT and cGMP for handheld manufacturing platform. - Test prototype device for treatment of intracranial hemorrhage using laser energy through skull and tissues and engage with FDA on GMP.			
Title: Military Medical Imaging ***Description:*** 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 thrust will examine the capability for new, portable spectroscopic techniques that can provide information for military medical use (e.g., analysis of traumatic brain injury) that is superior to that provided by an MRI. 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. Finally, this thrust will allow safe, non-invasive detection of microscopic and functional alterations within tissues and organs of a living organism at early stages of injury. The advanced development of these tools will provide a formidable arsenal of diagnostic tools for warfighter performance and care. ***FY 2012 Accomplishments:*** - Developed software to convert disparate data formats into a common language, enabling visual display and integration for processing queries. - Demonstrated ability to automatically detect, track, and analyze similar events and incidents in temporal and physical space. - Conducted experiments to investigate the use of orbital angular momentum (OAM) in Terahertz (THz) spectroscopy and verify the theory describing photon OAM - molecule interaction theory. - Initiated the design of high efficiency X-ray optics appropriate for broadband, bench top X-ray sources. - Began experimenting with arrays of OAM photon beams and modeled new signal detection approaches in order to increase the signal-to-noise ratio and to hyperpolarize a larger volume. ***FY 2013 Plans:*** - Demonstrate, using a model of skin and bone, that X-rays focused with OAM can yield image and chemical analysis superior to an MRI without the use of a large magnet to hyperpolarize the nuclei.	7.144	6.400	2.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Investigate options for broadband nuclear magnetic resonance detection for the simultaneous acquisition of multiple nuclear species. ***FY 2014 Plans:*** - Design a compact prototype device for performing novel MRI-like imaging and spectroscopy using quantum orbital resonance spectroscopy (QORS) in military medical environments. - Obtain neurochemical spectra using QORS technique.			
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. 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 Accomplishments:*** - Evaluated existing sensing, microfluidic flow, and intrinsic separation component technologies for use in an integrated blood purification system and initiated research plan to achieve significant improvements in line with the overall program goals. - Initiated integration plan for component technologies developed in the basic research aspect of this program. - Identified a regulatory pathway leading to an approved integrated device. ***FY 2013 Plans:*** - Refine integration strategy, develop a bread-board system, and demonstrate bread-board system. - Develop appropriate animal models, confirm regulatory plan, and begin regulatory approval process for the integrated device. ***FY 2014 Plans:***	5.000	10.000	20.000

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Integrate continuous sensing, biocompatible high-flow fluid manipulation, intrinsic separation from complex fluid, and predictive modeling and control in a prototype device for the treatment of sepsis. - Use feedback from initial animal model testing to inform the development of a prototype device for additional safety and efficacy studies in a large animal model. - Continue regulatory approval process and initiate plan for investigational device exemption submission.			
Title: Warrior Web ***Description:*** Musculoskeletal injury and fatigue to the warfighter caused by dynamic events on the battlefield not only impacts immediate mission readiness, but also can have a deleterious effect on the warfighter throughout his/her life. The Warrior Web program will mitigate that impact by developing an adaptive, quasi-active, joint support sub-system that can be integrated into current soldier systems. Because this sub-system will be compliant and be transparent to the user, it will reduce the injuries sustained by warfighters while allowing them to maintain performance. Success in this program will require the integration of component technologies in areas such as regenerative kinetic 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 9kg and require no more than 100W of external power. Allowing the warfighter to perform their missions with reduced risk for injuries will have immediate effects on mission readiness, soldier survivability, mission performance and the long-term health of our veterans. This effort was previously funded in the Maintaining Combat Performance Thrust in PE 0602715E, Project MBT-02. ***FY 2013 Plans:*** - Complete injury assessment and component technology integration into open source biomechanical model. - Complete initial verification and validation of component technologies in military environments. - Conduct Preliminary Design Review to demonstrate that individual component technologies (e.g., energy, actuation) can be integrated to meet Warrior Web performance requirements. ***FY 2014 Plans:*** - Leverage open source biomechanical model to iterate design. - Complete component technology based on results of Preliminary Design Review. - Initiate design of full Warrior Web including integration into current solider system. - Conduct Critical Design Review of full Warrior Web solider system combination.	0.000	10.750	12.000
Title: Revolutionizing Prosthetics* ***Description:*** *Previously funded in PE 0602715E, Project MBT-02.	0.000	17.000	10.000

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
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 months to support use in human research participants. - Support design modifications of neural recording and stimulation devices to reduce patient burden and gain Food and Drug Administration (FDA) approval for commercialization. - Complete FDA requirements, additional human trials and testing, to gain commercial transition of non-invasively controlled prosthetic arm system. ***FY 2014 Plans:*** - Support pre-launch activities of non-invasively controlled prosthetic arm system. - Demonstrate brain control of bilateral prosthetic arms simultaneously. - Incorporate design updates in prosthetic arm systems to improve reliability and reduce cost. - Continue human spinal cord injured patient trials demonstrating longevity of cortical control.			
Title: Restoration of Brain Function Following Trauma ***Description:*** The Restoration of Brain Function Following Trauma program will exploit recent advances in the understanding and modeling of brain activity and organization to develop approaches to treat traumatic brain injury (TBI). Critical to success will be the ability to detect and quantify structural and molecular changes produced in the human brain from explosive blast and correlate those changes with neurocognitive evaluation. This program will also develop technologies for monitoring and controlling the cells responsible for immune and regenerative responses in the human body. The ultimate goal is identification of efficacious therapeutics or other therapies that can halt progression of injury and/or reduce the severity or duration of TBI. This program is a follow-on to a basic research effort funded under Human Assisted Neural Devices in Program Element 0601117E, Project MED-01. ***FY 2014 Plans:***	0.000	0.000	8.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Develop a platform prototype computational model of neural activity that integrates neural activity of brain structures at numerous scales and across anatomically distributed regions. - Develop approaches to detect and model the structural and molecular changes produced in the human brain during explosive blast.			
Title: Translational Understanding of Blast Effects (TransBlast) ***Description:*** The TransBlast program is a prospective longitudinal study designed to rapidly advance understanding of blast-induced neurotrauma by closely coupling the biomechanical, medical, blast physics, and event measurement components into an integrated effort. The program will follow high-risk populations of service members to elucidate injury from both isolated and repeated events. Service members in the program are tested with a combination of imaging and neurocognitive functional exams prior to training, after training workup-but before deployment, and again after deployment. During training and deployed operations the service members wear blast dosimetry systems to document any exposures. All exposures are analyzed through detailed 3-dimensional reconstructions, combined with medical evaluations and testing records to determine the complex relationships between mechanical properties of blasts and the initiation of pathophysiologic responses. This effort builds on the successful deployment of the Blast Gauge measurement system in association with clinical indices of neurologic and psychiatric status to define a quantifiable relationship between timing and intensity of blast exposures and development and recovery of physiologic and clinic changes in an active duty population exposed to repetitive sub-clinical blast exposures and at an increased risk of involvement in clinically significant blast events. ***FY 2014 Plans:*** - Complete program protocols and gain Institutional Review Board approval. - Work with military units to complete population selections with emphasis on service members that are at high-risk for blast exposure based on: their military role, the unit in which they operate, their anticipated deployments, and their probable availability for 4 years. - Complete baseline testing of selected populations. Test regiment will be constructed to balance gaining structural and functional information on each service against the need to minimize impact on the training regiment. - Outfit all service members in the program with blast dosimetry system (Blast Gauge) to ensure that events in training and combat operations are recorded. - Complete training of all medical support teams in units and areas of operation on how to use Blast Gauges and recover data from them. - Deploy support personal at training locations and forward locations to match the training and deployed requirements of the service members.	0.000	0.000	5.000
Title: Detection and Computational Analysis of Psychological Signals (DCAPS) - Medical*	0.000	8.100	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Description: *Funded in PE 0602304E, Project COG-03 in FY 2012 The Detection and Computational Analysis of Psychological Signals (DCAPS) program is developing automated information systems that identify group and individual trends indicative of post-traumatic stress disorder (PTSD) and traumatic brain injury (TBI) and anomaly detection algorithms that identify emerging physical and psychological crises. These will complement commercial offerings that 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 incorporates strong authentication and other security mechanisms as needed to protect patient data. The program is also developing 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.			
Title: Unconventional Therapeutics ***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. 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 Accomplishments:*** - Demonstrated 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. - Demonstrated a 4-fold increase in survival time after a lethal dose challenge of a given pathogen in an animal model due to administered technology. - Demonstrated 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.	7.359	3.000	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated 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.			
Title: Reliable Neural-Interface Technology (RE-NET) ***Description:*** Wounded warriors with amputated limbs cannot exploit recent advances in prosthetic-limb technology because the interfaces used to extract limb-control information are low-performance and unreliable. The goal of the Reliable Neural Technology (RE-NET) program is to develop the technology and systems needed to reliably extract motor-control information 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 and model 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 Accomplishments:*** - Developed peripheral nerve recording interfaces and control algorithms that capture motor intent signals from the residual nerves in amputees, a relatively non-invasive surgical technique that directly acquires nervous system activity. - Developed a flexible clinical-grade electromyography-lead technology integrated with an implantable myoelectric sensor (IMES), a very small single-channel wireless telemetry system, ready for clinical translation toward use by DoD amputees. - Developed and preliminarily demonstrated a living peripheral-nerve interface (micro targeted muscle reinnervation [microTMR]), that forms a long-term and reliable connection between single motor fascicles from a peripheral nerve that are implanted into individual muscle fiber transplants. - Developed and preliminarily demonstrated high-channel-count flat interface nerve electrodes (FINE), which when placed around individual peripheral nerves, can be used to record motor-control information. - Developed and demonstrated new pattern-recognition algorithms that can process motor-control information extracted from targeted muscle reinnervation (TMR) patients, and for the first time, provide simultaneous control of two or more degrees of freedom in the prosthetic limbs used by existing DoD amputees with TMR. - Demonstrated the ability to stimulate sensory-nerve activity and record motor-nerve activity through electrodes placed in the spinal cord dorsal root ganglion and ventral root respectively. - Developed and demonstrated a high-precision upper-limb motion-capture system capable of simultaneously tracking 28 degrees of freedom in real time.	24.000	10.150	0.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Developed sophisticated real-time classification algorithms designed to operate dexterous control of an upper limb neuroprosthetic using EEG and non-biological signals captured entirely from non-invasive, non-penetrating, sources without the surgical risks associated with neural implants. - Identified significant microprobe degradation following chronic invasive implantation into the cortex of the brain. ***FY 2013 Plans:*** - Demonstrate human amputee use of clinical-grade DARPA RE-NET-developed peripheral-interface technologies that capture motor-control intent from endogenous nerves and muscle tissue. - Complete safety and efficacy testing of a flexible clinical-grade electromyography-lead technology integrated with an implantable myoelectric sensor (IMES), is a very small single-channel wireless telemetry system. - Submit and receive investigational-device-exemption (IDE) approval from the Food and Drug Administration (FDA) for testing leaded IMES in human amputees. - Complete safety and efficacy testing of implanted thin-film longitudinal intrafascicular electrodes (tfLIFE) and micro-targeted-muscle-reinnervation (microTMR) interfaces and plan experiments to demonstrate the ability to control prosthetic limbs. - Complete and demonstrate an implantable, reliable, and biocompatible electronics package capable of amplifying and processing motor-control signals detected by high-channel-count flat interface nerve electrodes (FINE). Perform safety and efficacy testing of implanted high-channel-count FINE interfaces. Prepare FDA IDE application submission. - Demonstrate a small implantable RF-powered electronics package capable of amplifying, processing, and wirelessly transmitting electromyography-based motor-control signals, such as those involved with TMR and microTMR. - Demonstrate an EEG-based fully non-invasive, non-penetrating, neural-interface system capable of providing prosthetic limb control for unconstrained human users. - Develop and demonstrate real-time control of a 28 degree-of-freedom avatar using decoded neural activity from the motor cortex of the brain.			
Title: Preventing Violent Explosive Neurologic Trauma (PREVENT) ***Description:*** The Preventing Violent Explosive Neurologic Trauma (PREVENT) program illuminated 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 used 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 worked to create a model that can be directly correlated to the epidemiology and etiology of injury seen in returning warfighters, and attempted to determine the physical and physiological underpinnings and causes of the injury. Raw data was collected from in-theater blast gauges, along with medical and event reports to form a comprehensive analysis. As part of the mitigation and treatment strategy, candidate therapeutics were tested in order to alleviate inflammation from both acute and chronic injury. ***FY 2012 Accomplishments:***	3.766	0.000	0.000

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Continued study on blast-exposed warfighters using magnetic resonance spectroscopy (MRS) imaging post-deployment showed, for the first time, injury to the hippocampus, the part of the brain associated with learning and memory, and correlated with memory deficits. - Studied animal models to evaluate the impact of blast pressure on the brain, which showed structural neuropathological and molecular changes along with neurobehavioral changes, and confirmed that pure blast pressure can injure the brain. - Replicated some of the changes seen in the blast exposed warfighters in the animal model, such as injury to the hippocampus. - Developed potential therapeutic agents for treating blast TBI in warfighters.			
Accomplishments/Planned Programs Subtotals	95.661	110.900	114.790

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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COST ($ in Millions)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	343.383	392.421	413.260	-	413.260	393.462	357.192	368.037	391.760	Continuing	Continuing
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	-	72.569	96.697	105.691	-	105.691	85.092	89.556	111.704	130.704	Continuing	Continuing
IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*	-	179.901	174.295	172.004	-	172.004	175.274	179.695	195.085	204.808	Continuing	Continuing
IT-04: *LANGUAGE TRANSLATION*	-	66.430	71.429	75.098	-	75.098	71.248	57.941	61.248	56.248	Continuing	Continuing
IT-05: *CYBER TECHNOLOGY*	-	24.483	50.000	60.467	-	60.467	61.848	30.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	354.125	392.421	428.541	-	428.541
Current President's Budget	343.383	392.421	413.260	-	413.260
Total Adjustments	-10.742	0.000	-15.281	-	-15.281
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.091	0.000			
• SBIR/STTR Transfer	-9.651	0.000			
• TotalOtherAdjustments	-	-	-15.281	-	-15.281

Change Summary Explanation

FY 2012: Decrease reflects reductions for the SBIR/STTR transfer and internal below threshold reprogrammings.

FY 2014: Decrease reflects minor repricing.

Exhibit R-2A, **RDT&E Project Justification:** PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	-	72.569	96.697	105.691	-	105.691	85.092	89.556	111.704	130.704	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: META	34.000	50.000	40.691
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 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 re-programmability, 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. ***FY 2012 Accomplishments:*** - Matured 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.			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Developed a domain-specific component model library for the drivetrain/mobility subsystems of a military ground vehicle through extensive characterization of desirable and spurious interactions, dynamics, and properties of all physics domains. - Developed context models to reflect various operational environments. - Developed and implemented an infrastructure for publishing and maintaining detailed component models using an ontology incorporating NATO taxonomies to expand the design space for subsequent efforts to design and build a military ground vehicle. - Developed a mechanism for the feedback of manufacturability constraints into the design and design tradespace exploration process. - Developed and integrated a library of 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 the chassis and survivability subsystems of an amphibious infantry fighting vehicle (IFV) through extensive characterization of desirable and spurious interactions, dynamics, and properties of all physics domains. - Transmit the winning design from the first Fast Adaptable Next Generation Ground (FANG) Challenge to the iFAB foundry for fabrication of an IFV drivetrain and mobility subsystem. - Begin expanded development of META tool suite to include qualitative and relational abstraction modeling, probabilistic certificate of correctness calculations, complexity metric evaluation, non-linear Partial Differential Equation (PDE) analysis and cyber design evaluation. ***FY 2014 Plans:*** - Develop domain-specific component model library for a full amphibious IFV through extensive characterization of desirable and spurious interactions, dynamics, and properties of all constituent components down to the numbered part level. - Transmit the winning design from the second FANG Challenge to the iFAB foundry to fabricate an IFV chassis and integrated survivability subsystem. - Complete development of full META tool suite necessary for the third FANG Challenge.			
Title: Instant Foundry Adaptive Through Bits (iFAB)* ***Description:*** *Formerly part of the META Program Instant Foundry Adaptive Through Bits (iFAB), will lay the groundwork for the development of a foundry-style manufacturing capability--taking as input a verified system design specified in an appropriate metalanguage--capable of rapid reconfiguration to accommodate a wide range of design variability and specifically targeted at the fabrication of military ground vehicles. The iFAB vision is to move away from wrapping a capital-intensive manufacturing facility around a single defense product, and toward the	18.000	20.000	26.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
creation of a flexible, programmable, potentially distributed production capability able to accommodate a wide range of systems and system variants with extremely rapid reconfiguration timescales. The specific goals of the iFAB program are to rapidly design and configure manufacturing capabilities to support the fabrication of a wide array of infantry fighting vehicle models and variants. Once a given design is developed and verified, iFAB aims to take the formal META design representation and automatically configure a digitally-programmable manufacturing facility, including the selection of participating manufacturing facilities and equipment, the sequencing of the product flow and production steps, and the generation of computer-numerically-controlled (CNC) machine instruction sets as well as human instructions and training modules. iFAB is mostly an information architecture. Only the final assembly capability needs to be co-located under a single roof in anything resembling a conventional fabrication facility; the rest of iFAB can be geographically distributed and can extend across corporate and industrial boundaries, united only by a common model architecture and certain rules of behavior and business practices. The final assembly node of the iFAB facility for infantry fighting vehicles (IFV) is currently slated to be at the Joint Manufacturing and Technology Center at the Rock Island Arsenal. ***FY 2012 Accomplishments:*** - Began the assembly and integration of foundry-style manufacturing capability for military ground vehicles. - Developed coarse-level determination of manufacturability time and cost for traditional and composite designs from Computer-Aided Design (CAD) models of moderate complexity. - Created a manufacturing library describing machine tools, processes, and human capabilities for application to the Fast Adaptable Next Generation Ground (FANG) vehicle challenges. - Developed an open source visualization of a foundry, including distributed network and assembly facility, for the verification and accurate assessment of time/accessibility/reachability for human operations within the foundry. - Defined manufacturing requirements for drivetrain and mobility subsystem, including 140+ standard fixtures. - Developed an open source assembly planner using collision detection tools to determine possible build sequences. - Coordinated placement of iFAB Foundry final assembly facility at the Joint Manufacturing Technology Center at Rock Island Arsenal, IL. ***FY 2013 Plans:*** - Conduct a preliminary design review and critical design review (CDR) for the iFAB Foundry. - Mature and integrate foundry infrastructure tools developed under iFAB, including manufacturing feedback and process planning. - Develop foundry infrastructure tools to assess assembly processes and requirements. - Upgrade the Rock Island Arsenal final assembly facility of the iFAB Foundry, and install equipment for the first FANG challenge for an amphibious IFV drivetrain and mobility subsystem.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Test process planning, manufacturing assessment and building capabilities of the distributed foundry through pre-challenges in preparation for the first FANG challenge for an IFV drivetrain and mobility subsystem. - Provide manufacturability feedback to the META design process in support of the first FANG challenge for an IFV drivetrain and mobility subsystem. - Reconfigure the iFAB foundry and build the winning drivetrain and mobility subsystem design from the first FANG Challenge. ***FY 2014 Plans:*** - Conduct a CDR for changes required within Foundry for building an IFV chassis and survivability subsystem. - Provide manufacturability feedback to the META design process in support of the second FANG challenge for an IFV chassis and survivability subsystem. - Reconfigure the iFAB foundry and build the winning chassis and survivability subsystem design from the second FANG Challenge.			
Title: Power Efficiency Revolution For Embedded Computing Technologies (PERFECT) ***Description:*** 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 within real-world embedded system power constraints. 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 near threshold voltage operation, massive and heterogeneous processing concurrency, new architecture concepts, and 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 2012 Accomplishments:*** - Completed Ubiquitous High Performance Computing (UHPC) high level architectural designs. - Released runtime system support tools for attributing runtime costs and pinpointing system performance and stability bottlenecks. - Developed interactive compilation framework incorporating affine (linear loop parallelization) and software pipelining (find and exploit parallelization in serial codes) optimizations to automate code parallelization. - Released 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:***	15.337	26.697	35.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- 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. - Identify key language extensions and approaches required for the development of massively parallel software. ***FY 2014 Plans:*** - Develop an analytical modeling framework for fundamental design trade-off analysis and documentation for local resilience and power optimizations and global optimization methodologies and techniques. - Establish algorithmic analysis and design methodologies for power efficient and resilient processing. - Define power efficient, heterogeneous, highly concurrent conceptual architectural design approaches. - Define and evaluate the impact of 3D approaches for power efficient processing.			
Title: Adaptive Integrated Reliability ***Description:*** The Adaptive Integrated Reliability program goals are to leverage real-time monitoring and the ability to effect fine-grained real-time control to significantly increase the lifecycle reliability of complex aerospace and defense systems. The program will also develop and demonstrate technology to reduce the incidence of catastrophic failure in complex aerospace defense systems through real-time detection and adaptation. The program will develop novel in-situ prognostication and health monitoring techniques applicable to complex air and space platforms. The program will develop tractable approaches to predict, identify, and respond to failures endemic to complex systems such as failure cascades, destructive emergent behavior, and off-nominal responses. To accomplish this, the program will leverage recent advances in adaptive control for fault isolation and mitigation. Adaptive Integrated Reliability will culminate with installation of the integrated reliability management system on a complex air or space platform and demonstrate 2X reliability improvement via accelerated lifecycle testing with representative stimuli. This reliability enhancement capability will enable development of a new generation of dependable complex systems and enable the compression of system test timelines by trading off testing for lifecycle reliability. The requisite design and production tools and techniques developed in the program will have immediate application to space systems and aircraft programs. ***FY 2014 Plans:*** - Initiate development of the integrated reliability monitoring and prediction approach to include design, analysis, processing, and appropriate sensor and platform architectures. - Initiate development of embedded sensors that possess the requisite size, energy, and environmental durability to support the Adaptive Integrated Reliability approach.	0.000	0.000	4.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Initiate development of techniques for installation of the sensors during the platform fabrication processes.			
Title: High-Productivity Computing Systems (HPCS) ***Description:*** The High-Productivity Computing Systems (HPCS) program created a new generation of economically viable, high-productivity computing systems for the national security and industrial user communities. HPCS technologies were targeted at enabling 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 was 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 2012 Accomplishments:*** - Monitored the two HPCS performers until program completion and completed prototype demonstrations with stakeholders.	5.232	0.000	0.000
Accomplishments/Planned Programs Subtotals	72.569	96.697	105.691

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*	-	179.901	174.295	172.004	-	172.004	175.274	179.695	195.085	204.808	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Cyber Genome	24.000	15.949	5.500
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 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 2012 Accomplishments:*** - Created lineage trees for a class of digital artifacts to support malware evolution forensics. - Developed and demonstrated co-clustering and binary analysis techniques for automatically identifying re-used components in submitted malware samples. - Created graph-based displays of malware lineage and achieved 80% accuracy on samples with known relationships. ***FY 2013 Plans:*** - Develop techniques to automatically and reliably extract forensically-meaningful traits such as authorship, compiler, toolkit, and obfuscation techniques. - Enhance co-clustering and binary analysis techniques to enable the automatic identification of re-used components. - Develop operationally relevant use case test scenarios with transition partner and conduct initial use case validation tests.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Implement prototypes incorporating the most effective techniques to transition partner specifications. ***FY 2014 Plans:*** - Demonstrate significant improvement to provenance determination through the use of the automatically extracted traits. - Demonstrate final prototypes capable of detecting a single interesting targeted threat from a stream of at least 10K uninteresting mass-infection malware samples. - Evaluate the effectiveness of prototype systems in conjunction with transition sponsors and complete transition.			
Title: Integrity Reliability Integrated CircuitS (IRIS) ***Description:*** The integrated circuit (IC) is a core component of many electronic systems developed for the Department of Defense. However, the DoD consumes a very small percentage of the total IC production in the world. As a result of the globalization of the IC marketplace, much of the advanced IC production has moved to offshore foundries, and these parts make up the majority of ICs used in today's military systems. Without the ability to influence and regulate the off-shore fabrication of ICs, there is a risk that parts acquired for DoD systems may not meet stated specifications for performance and reliability. This risk increases considerably with the proliferation of counterfeit ICs in the marketplace, as well as the potential for the introduction of malicious circuits into a design. Through the IRIS program, DARPA seeks to develop techniques that will provide system developers the ability to derive the function of digital, analog and mixed-signal ICs non-destructively, given limited operational specifications. These techniques will include advanced imaging and device recognition of deep sub-micron Complementary Metal-Oxide Semiconductor (CMOS) circuits, as well as computational methods to solve the NP-complete problem of determining device connectivity. Finally, the IRIS program will produce innovative methods of device modeling and analytic processes to determine the reliability of an IC by testing a limited number of samples. The current understanding of IC aging mechanisms, including negative bias temperature instability (NBTI), hot carrier injection (HCI), time dependent dielectric breakdown (TDDB) and electromigration (EM) will be leveraged to develop unique diagnostic test techniques. ***FY 2012 Accomplishments:*** - Completed fabrication of digital and mixed-signal IC test articles for functional derivation and reliability studies. - Completed definition of functional requirements for algorithms that determine circuit functionality without prior knowledge of their underlying logic and design. - Demonstrated the ability to resolve design features of a CMOS 90nm IC for circuit extraction through non-destructive methods. - Demonstrated functional derivation of un-altered digital and mixed-signal ICs at the 45 nm CMOS node.	30.000	18.500	6.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated reliability derivation from reduced sample sizes of digital ICs at the 90 nm CMOS node and mixed-signal ICs at the 130 nm CMOS node. - Developed tools for functional derivation from third-party Intellectual Property (IP) blocks for both Application Specific Integrated Circuits (ASICs) and Field Programmable Gate Arrays (FPGAs). - Demonstrated the ability to observe free charges flowing in a 90 nm CMOS semiconductor device through the use of laser probing. - Demonstrated the ability to identify logic cell connections in 90 nm CMOS designs. ***FY 2013 Plans:*** - Demonstrate the ability to identify design primitives (transistors, capacitors, resistors, etc.), memory elements and interconnect through non-destructive imaging, and derive a "flattened" netlist from these components. - 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. - Develop digital and mixed-signal test articles appropriate for testing techniques for identifying unintended circuits and circuit functions. ***FY 2014 Plans:*** - Refine methods for non-destructive imaging, circuit extraction and functional derivation for improved accuracy and efficacy. - Refine methods for reliability analysis for improved accuracy, functionality and efficacy. - Encourage and support collaborative efforts among performers to develop cohesive and robust solutions for each technical thrust. - Establish advanced metrics to characterize and evaluate performer efforts for potential transition activity.			
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 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.	29.000	28.502	28.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Implemented two complete hardware tagged security processors capable of defeating common vulnerabilities and supporting novel, provably secure prototype operating systems. - Demonstrated full scale systems capable of detecting and recovering from penetrations. - Scaled automatic patch generation to more complete coverage and to work on commercial scale systems. - Automatically synthesized, using formal methods, hundreds of variants of a single distributed protocol, each of which is automatically proven correct. - Implemented a compiler that generates thousands of unique variants of programs that are demonstrated to be robust against return oriented programming attacks. - Developed a virtualization environment that provides improved security, better performance, and new functionality compared to current approaches. - Demonstrated a 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. - Transitioned CRASH network software development, retroactive patching, and code anti-tamper technologies to commercial industry. ***FY 2013 Plans:*** - Demonstrate moving target defense with automatically constructed diverse implementations of algorithms and programs. - Implement web-based application on secure operating systems and verify its resistance to attacks through heterogeneity. - Produce formally-verified operating system kernel modules. - Integrate tagged security processor prototypes with secure operating system, development environments for correct-by-design software, and multiple applications. - 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 into commercial router for military use. ***FY 2014 Plans:*** - Produce and demonstrate automation tools for constructing formally-verified operating system kernels. - Automatically produce diverse instantiations of one or more complete operating systems. - Deliver web server that enables creation of secure web sites from untrusted code. - Demonstrate real-time, continuous validation of system compliance with security specifications. - Demonstrate the ability of two or more complete systems to block, survive, and recover from multiple attacks and automatically repair vulnerabilities.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Validate security of systems and prototypes through red team and external challenges. - Transition CRASH research products into one or more embedded systems.			
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 compute an encrypted search result without decrypting the query. This technology will advance the capability 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 2012 Accomplishments:*** - Demonstrated enhanced security and availability capabilities with an order of magnitude increase in scalability and support for full web access in addition to existing applications. - Performed initial independent, adversarial assessment of the effectiveness of SAFER technologies to prevent communication localization and detection. - Continued development of decoy routing to support unblockable connectivity short of complete disconnection from the Internet. - Implemented rich policy support for onion routing to enhance anonymity in the face of compromised routers. - Performed initial, independent benchmarks of fully homomorphic encryption, garbled-circuit secure multiparty computation, and secret-sharing secure multiparty computation. - Computed benchmarks of the fully homomorphic encryption evaluation of the Advanced Encryption Standard demonstrating more than an order of magnitude performance improvement. - Started design for program-wide application programming interface (API) for encrypted computation using either fully homomorphic encryption or secure multiparty computation. - Designed program-wide API for low level mathematics to support encrypted computation using either fully homomorphic encryption or secure multiparty computation. - Demonstrated optimized software implementations of second generation fully homomorphic encryption algorithms. ***FY 2013 Plans:*** - Perform follow up independent, adversarial assessment of the effectiveness of SAFER technologies to prevent communication localization and detection, including newly developed adversarial techniques.	20.000	17.680	15.150

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate field programmable gate array implementation of fully homomorphic encryption offering an order of magnitude 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. - Demonstrate two orders of magnitude improvement in performance of fully homomorphic encryption. - 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. ***FY 2014 Plans:*** - Integrate decoy routing, parallelized group messaging, dynamic traffic camouflage, and rendezvous strategy technologies into common internet browsing applications. - Demonstrate safe, anonymous internet communications applications such as web access, Voice over Internet Protocol (VOIP), and streaming video, at scale. - Conduct the final independent, adversarial assessment of the effectiveness of SAFER technologies to prevent communication localization and detection, including newly developed adversarial techniques. - Reduce ciphertext expansion while improving software performance in fully homomorphic encryption, garbled-circuit secure multiparty computation, and secret-sharing secure multiparty computation, and perform independent benchmarks. - Refine field programmable gate array implementation of fully homomorphic encryption to yield a further order of magnitude performance improvement over optimized software implementation.			
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 2012 Accomplishments:*** - Prototyped a scalable, distributed architecture to correlate relevant data from heterogeneous sources over extended periods of time. - Formulated techniques for determining whether a system, individual, or group/organization is exhibiting anomalous behavior suggestive of a threat. - Created an experimental testbed that includes real-world data sets at scale and supports novel red-teaming capabilities.	20.000	15.000	14.612

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Initiated assessment and validation of insider-threat indicators with counter-intelligence transition partners. ***FY 2013 Plans:*** - Refine and create techniques for detecting malicious insiders, delineate assumptions/conditions under which they are valid/invalid, and specify their effective combination. - Create a comprehensive library of test data and quantify probabilities of detection and false alarm for anomalous non-threat and threat behaviors. - Develop technologies to manage the number of anomalies, focus computing resources on ambiguous results, and prioritize threats. - Demonstrate the capability to identify anomalous behavior suggestive of a threat in real time on streaming data. ***FY 2014 Plans:*** - Develop and implement technology to capture analyst expertise for assessing and explaining detected anomalies and for incorporating such user feedback in ADAMS decision loops. - Develop an integrated prototype anomaly/threat detection system suitable for rapid deployment in an operational environment. - Harden ADAMS prototype and obtain approval for use on military networks including DOD Information Assurance Certification and Accreditation Process (DIACAP) certification. - Conduct and evaluate initial ADAMS implementation in an operational environment.			
Title: Mission-oriented Resilient Clouds* ***Description:*** *Formerly Resilient Clouds The Mission-oriented Resilient Clouds (MRC) 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. MRC 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. MRC will create new approaches to measuring trust, reaching consensus in compromised environments, and allocating resources in response to current threats and computational requirements. MRC will develop new verification and control techniques for networks embedded in clouds that must function reliably in complex adversarial environments. ***FY 2012 Accomplishments:*** - Identified algorithmic advances and protocol re-design opportunities and requirements to achieve high levels of assurance in networked/cloud computing systems. - Delivered library of new algorithms and protocols for high-assurance computation in networked/cloud computing systems.	20.389	23.500	28.071

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Developed techniques for presenting a diverse, changing target to attackers without impacting the usability of applications running on these systems. - Created approaches and algorithms for expanding self-monitoring hosts into a cooperative self-monitoring cloud. - Demonstrated new algorithms to dynamically reallocate prioritized network resources. - Implemented a new resilient microkernel on both cloud and embedded hardware platforms. - Refined cloud security requirements with DISA and focused specific projects on activities that will support future transitions into DISA and other DoD organizations. ***FY 2013 Plans:*** - Develop new behavior-based algorithms for detecting compromised machines. - Measure the effectiveness of new algorithms and protocols for high-assurance computing in cloud computing systems that are under attack. - Validate that new components are addressing resilience goals through independent red-team assessments. - Demonstrate a cloud computing environment that produces correct, mission-relevant results when individual computing and network elements have been compromised. - Develop intrusion-tolerant communication protocols for cloud monitoring and control. - Validate the extension of host-level monitoring and adaptation to cloud-level monitoring and adaptation. - Begin evaluating multiple MRC technologies in DISA testbeds to facilitate transitions into DoD clouds. ***FY 2014 Plans:*** - Produce a cloud task allocation system that maximizes mission effectiveness by employing redundancy in the context of current system loads without significantly increasing hardware costs. - Implement a trustworthy programmable switch controller. - Demonstrate dynamic adjustment of replication and communications in response to estimated and predicted attack levels. - Implement self-healing functionality for cloud applications. - Transition MRC research products into DoD cloud environments.			
Title: High Assurance Cyber Military Systems ***Description:*** 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	8.250	16.064	23.117

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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 Accomplishments:*** - Performed detailed requirements and systems engineering analyses to identify embedded devices requiring high assurance levels and a corresponding concept of operations. - Produced a high-level design for identified embedded computing platforms that provides a high level of assurance for military users. - Developed approaches to reduce the time to produce high-assurance embedded systems by leveraging existing high assurance systems, both through a modular architecture and through tool reuse. ***FY 2013 Plans:*** - Perform static and dynamic baseline assessments of selected militarily relevant vehicles before any modifications are made. - Develop initial techniques and build prototype tools to assist in the rapid creation of high-assurance embedded computing systems on a variety of vehicles. - Construct core pieces of a high-assurance embedded operating system and attack-resilient control system for two militarily relevant vehicles using developed tools and techniques. - Formally verify full functional correctness for core operating system and targeted control-systems for selected vehicles. - Demonstrate required security properties that follow from correctness. ***FY 2014 Plans:*** - Demonstrate compositionality which is the ability to construct high assurance systems out of high assurance components. - Extend the core high-assurance embedded operating system with additional functionality, including automatically generated device drivers and communication protocols. - Automatically synthesize correct-by-construction control systems from high-level specifications. - Perform static and dynamic assessments after modifications are made on the militarily-relevant vehicles to evaluate the effectiveness of the synthesis and formal-methods tools.			
Title: Vetting Commodity Computing Systems for the DoD* ***Description:*** *Previously part of High Assurance Cyber Military Systems	0.000	7.000	16.954

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
The Vetting Commodity Computing Systems for the DoD (VET) program will develop tools and methods to uncover backdoors and other hidden malicious functionality in the software and firmware on commodity IT devices. The international supply chain that produces the computer workstations, routers, printers, and mobile devices on which DoD depends provides many opportunities for our adversaries to insert hidden malicious functionality. VET technologies will also enable the detection of software and firmware defects and vulnerabilities that can facilitate adversary attack. ***FY 2013 Plans:*** - Create supply chain attack scenarios, formulate program analysis approaches, specify diagnostic tool functionality, develop relevant Application Programming Interfaces (APIs), and define formal semantics for the programming languages to be analyzed. - Develop the initial infrastructure required to support the development of a sufficient number of challenge programs containing hidden malicious functionality to support realistic evaluations. ***FY 2014 Plans:*** - Produce initial prototype attack scenario generation, program analysis, and diagnostic tools. - Produce initial set of challenge programs for use in the first competitive engagement. - Perform the first competitive engagement between research and adversarial challenge performers to produce measurements of research progress against program metrics.			
Title: Logan* ***Description:*** *Previously part of Cyber Fast Track The Logan program will provide DoD enhanced capabilities to conduct Computer Network Attack (CNA). Techniques will be developed to disrupt and degrade adversary information systems and network operations, with particular interest in techniques likely to be robust to adversary countermeasure strategies. ***FY 2013 Plans:*** - Formulate CNA techniques and implement in initial software routines. - Develop manual prototypes for operational transition. ***FY 2014 Plans:*** - Automate and test prototypes in conjunction with transition partner. - Optimize and harden prototypes and complete transition.	0.000	6.000	13.100
Title: Integrated Cyber Analysis System (ICAS)* ***Description:*** *Previously part of Cyber Insider Threat (CINDER) in PE 0603760E, Project CCC-04.	0.000	3.000	9.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
The Integrated Cyber Analysis System (ICAS) program will develop techniques to automate the discovery of probes, intrusions, and persistent attacks on enterprise networks. At present, discovering the actions of capable adversaries requires painstaking forensic analysis of numerous system logs by highly skilled security analysts and system administrators. The ICAS program will develop technologies to correlate interactions and behavior patterns across all system data sources and thereby rapidly uncover aberrant events and detect compromise. This includes technologies for automatically representing, indexing, and reasoning over diverse, distributed, security-related data and system files. ***FY 2013 Plans:*** - Develop techniques for transforming log/system file formats into a unified schema as the basis for an actionable view of enterprise operational security. - Develop indexing schemes specialized to system files/security data and suitable for use across federated enterprise architectures. - Develop a rigorous, quantitative, risk-management framework to serve as the basis for automated real-time network forensics and rapid detection of targeted attacks and persistent threats. ***FY 2014 Plans:*** - Develop and implement algorithms for automatically identifying and quantifying specific security risks extant on an enterprise network. - Integrate, evaluate, and optimize algorithms via testing against targeted attack/persistent threat scenarios provided by potential DoD users. - Initiate transition of the most promising technologies to enterprises throughout the DoD.			
Title: Active Cyber Defense (ACD) ***Description:*** The Active Cyber Defense (ACD) program will enable DoD cyber operators to more fully leverage their inherent home field advantage when defending the cyber battlespace. For example, in the cyber environment the defender has detailed knowledge of and unlimited access to the system resources that the attacker is attempting to compromise. ACD technologies, drawn from discoveries realized in the Cyber Fast Track program, will build on these advantages and increase the attacker's work factor by enabling cyber defenders to counter adversary cyber tradecraft in real time. ***FY 2013 Plans:*** - Formulate concepts for shaping the cyber battlespace in ways that benefit cyber defenders. - Develop approaches for countering adversary cyber tradecraft. ***FY 2014 Plans:*** - Implement techniques for countering adversary cyber tradecraft in early prototype software applications.	0.000	5.300	12.500

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate and evaluate active cyber defense early prototypes and initial capabilities in exercises with transition partners.			
Title: Cyber Fast Track ***Description:*** 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. ***FY 2012 Accomplishments:*** - Made 77 contract awards, 22 of which have already resulted in successful field demonstrations, covering a broad range of cyber security technologies including detection and correction of software vulnerabilities, mobile device security, penetration testing automation, trust, traffic analysis, and wireless security. - Developed and demonstrated tools, methods, and techniques to reduce attack surface areas. - Refined pop-up threat list with CYBERCOM and coordinated work with other potential transition sponsors including NSA, AFRL, and the Navy Cyber Warfare Development Group. ***FY 2013 Plans:*** - Further expand outreach to additional potential customers/transition sponsors. - Complete efforts and transition technologies. - Transition of the Cyber Fast Track business model to DoD agencies.	10.000	17.800	0.000
Title: Rapid Planning (RP) ***Description:*** The Rapid Planning (RP) program developed planning and replanning tools for rapid generation and adaptation of robust plans in the presence of uncertainty, imprecision, incomplete, and contradictory data and assumptions. These enable the capability to monitor plans and continuously replan. RP addressed the need for mathematical methods to improve optimization including new branch and bound, mixed integer programming, and sub-modularity methods. ***FY 2012 Accomplishments:*** - Developed tools to facilitate various aspects of the mission planning process including formal plan representation, task sequence and timing analysis, mixed-initiative/man-machine interaction, and robust plan generation. - Created a "Mobile Task Assistant" portable workflow/collaborative planning application.	9.169	0.000	0.000
Title: Trusted Software ***Description:*** The Trusted Software program addressed 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	9.093	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
tools, the software engineers create errors and redundancies providing unintended and exploitable security flaws. This program developed specific techniques for building and validating trustworthy software. ***FY 2012 Accomplishments:*** - Developed an approach for automatically detecting and correcting integer-related vulnerabilities in source code. - Formulated a code protection technique that will provide a means to determine if an application is running in its original state or if it has been modified.			
Accomplishments/Planned Programs Subtotals	179.901	174.295	172.004

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency			**DATE:** April 2013
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COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
IT-04: *LANGUAGE TRANSLATION*	-	66.430	71.429	75.098	-	75.098	71.248	57.941	61.248	56.248	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

The Language Translation 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 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 2012**	**FY 2013**	**FY 2014**
Title: Broad Operational Language Translation (BOLT)	25.907	44.062	49.729
Description: The Broad Operational Language Translation (BOLT) program will enable communication regardless of medium (voice or text) or genre (conversation, chat, or messaging) through new approaches to automated language translation, human-machine multimodal dialogue, and language generation. 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 language sources. The program will also enable sophisticated search of stored language information and analysis of the information by enabling machines to perform deep language comprehension. ***FY 2012 Accomplishments:*** - Developed algorithms for processing and translating the informal genres used in Arabic and Chinese internet chat by automatically analyzing and interpreting unstructured language and handling incorrect or incomplete syntax. - Created and annotated two-million word web discussion group corpora for both Arabic and Chinese including translation, word alignment, and grammatical analysis.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Developed databases, tools, and algorithms to analyze and translate Egyptian dialectal Arabic including methods to compute the differences in the lexicon, morphology, and grammar between Egyptian dialectal Arabic (used in informal settings) and Modern Standard Arabic (used in newswire and broadcasts). - Developed initial methods and algorithms for machines to perform sophisticated search of informal genres including pragmatic analysis to retrieve information and remove redundancies. - Developed the means to detect errors in automatic speech recognition (e.g., incorrect choice of homonyms) and implemented these to create robust bi-lingual human-human dialogue systems. ***FY 2013 Plans:*** - Develop improved algorithms for processing and translating informal genres of Arabic and Chinese to enable comprehension of colloquialisms and idiomatic speech in a variety of dialects. - Expand the annotated corpora of Arabic and Chinese messages by adding new dialects and enhance utility by incorporating additional annotations. - Use methods developed for Egyptian dialectal Arabic to develop databases, tools, and algorithms to analyze and translate a second Arabic dialect. - Develop improved methods and algorithms for sophisticated search of informal genres of chats and messaging including techniques to remove redundancies through entailment analysis, synonym expansion, and homonym/homograph disambiguation. - Develop enhanced automatic speech recognition techniques capable of handling errors due to the occurrence of words outside the vocabulary of the machine as well as garbled speech and integrate these into a robust bi-lingual human-human dialogue system. ***FY 2014 Plans:*** - Develop a prototype robust machine translation system for colloquial Arabic and Chinese, handling multiple genres of text, conversational speech, disfluencies, and repetitions. - Add spoken colloquial data to the Arabic and Chinese annotated corpora. - Incorporate disambiguation capabilities into a robust machine translation prototype. - Optimize methods and algorithms for sophisticated search of the informal genres of chats, messaging, and conversational speech. - Improve the accuracy and usability of systems for human-human cross-language communication by incorporating robust error detection and correction techniques in human-machine dialogue systems.			
Title: Deep Exploration and Filtering of Text (DEFT)* ***Description:*** *Formerly Deep Extraction from Text	0.000	17.946	25.369

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
The Deep Exploration and Filtering of Text (DEFT) program will enable automated extraction, processing, and inference of information from text in operationally relevant application domains. A key DEFT emphasis is to determine the implied and hidden meaning in text through probabilistic inference, anomaly detection, and disfluency analysis. 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 databases. 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 methods to derive meaning from context for words that may have implicit or hidden meanings. - Develop methods and algorithms to infer implicit information from multiple facts and statements. - Implement algorithms to use domain knowledge to discover implicit/hidden meaning, answer questions, and make predictions. - Develop data sets and queries for science and technology, human-behavioral-social-cultural, and asymmetric threat domains. ***FY 2014 Plans:*** - Develop methods and algorithms for reasoning about both explicitly and implicitly expressed opinions and beliefs. - Develop methods for finding hidden meaning based on anomalous usages and disfluencies. - Develop methods and algorithms for extracting causal and implied knowledge from a document or set of documents. - Demonstrate feasibility of deep extraction and filtering for selected end-user applications.			
Title: Robust Automatic Translation of Speech (RATS) ***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 2012 Accomplishments:*** - Improved processing techniques for increasingly noisy environments, including speech activity detection, language identification, speaker identification, and keyword spotting. - Evaluated technology on program-generated data.	20.895	7.421	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Worked with transition partners to obtain field-collected data to train and test systems in realistic environments as a precursor to transition. ***FY 2013 Plans:*** - Finalize successful processing techniques for noisy environments, including speech activity detection, language identification, speaker identification, and keyword spotting and research additional techniques. - 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 is developing and integrating 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 2012 Accomplishments:*** - Improved the accuracy of MADCAT techniques. - Developed 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. - Work with newly-collected field data.	9.870	2.000	0.000
Title: Global Autonomous Language Exploitation (GALE) ***Description:*** The Global Autonomous Language Exploitation (GALE) program created 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 enhanced open-source intelligence and local/regional situational awareness by reducing the cost and effort of translation and analysis. GALE produced a fully-mature architecture and dramatically improved transcription and translation accuracy by broader exploitation of context. GALE technology developed timely alerts for commanders and warfighters.	9.758	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Supported incorporation of sophisticated search capabilities developed in the distillation task of GALE into selected systems. - Transitioned technologies to new customers in the intelligence community and operational commands.			
Accomplishments/Planned Programs Subtotals	66.430	71.429	75.098

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency			**DATE:** April 2013
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COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
IT-05: *CYBER TECHNOLOGY*	-	24.483	50.000	60.467	-	60.467	61.848	30.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

The Cyber Technology project develops technology to increase the security of military information systems and the effectiveness of cyber operations. Over the past decade the DoD has embraced net-centric warfare by integrating people, platforms, weapons, sensors, and decision aids. Adversaries seek to limit this force multiplier through cyber attacks intended to degrade, disrupt, or deny military computing, communications, and networking systems. Technologies developed under the Cyber Technology project will ensure DoD net-centric capabilities survive adversary cyber attacks and will enable new cyber-warfighting capabilities. Promising technologies will transition to system-level projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Foundational Cyber Warfare (Plan X)*	10.350	21.818	35.000
Description: *Formerly Cyber Situational Awareness The Foundational Cyber Warfare (Plan X) program will develop technologies to enable comprehensive awareness and understanding of the cyber battlespace as required for visualizing, planning, and executing military cyber warfare operations. This includes intelligence preparation of the cyber battlespace, indications and warning of adversary cyber actions, detection of cyber-attack onset, cyber-attacker identification, and cyber battle damage assessment. Plan X will also create new graphical interfaces that enable intuitive visualization of events on hosts and networks to aid in the planning and execution of cyber warfare. Plan X will extend operationally meaningful measures to project quantitatively the collateral damage of executed cyber warfare missions. ***FY 2012 Accomplishments:*** - Conceptualized new graphical interfaces enabling intuitive visualization of the cyber battlespace. - Created a cyber warfare domain specific language prototype. - Developed a robust list of cyber warfare scenarios that planners may encounter. - Prototyped a cyber warfare planning optimization and verification engine. ***FY 2013 Plans:*** - Finalize and implement the cyber warfare domain specific language. - Establish a testing infrastructure to simulate a real network topology of at least 5,000 nodes. - Deliver a Plan X version 1.0 prototype working with static network topology snapshots. - Initiate operation of a cyber planning and operations cell with military personnel.			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Prototype a hardened cyber weapon platform. ***FY 2014 Plans:*** - Release a Plan X version 2.0 prototype working with dynamic network topology snapshots. - Develop real-time network mapping updates and incorporate in planning and execution processes. - Finalize concept of operations for a cyber planning and operations cell. - Test on increasingly complex scenarios submitted by operational components.			
Title: Crowd Sourced Formal Verification (CSFV) ***Description:*** The Crowd-Sourced Formal Verification (CSFV) program 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 user-driven simulations that are intuitively understandable. ***FY 2012 Accomplishments:*** - Began development of approaches for mapping high-level formal software verification problems into user-driven simulations. - Identified and explored techniques for inferring specification and coding errors from the results of these simulations and for automatically generating the appropriate annotations. - Began architecture design for web-based infrastructure to support large scale program verification workflows. ***FY 2013 Plans:*** - Develop approaches for mapping high-level formal software verification problems into user-driven simulations. - Develop techniques for inferring specification and coding errors from the solutions to these simulations and for automatically generating the appropriate annotations to aid formal verification. - Develop web-based infrastructure to support large scale formal software verification workflows. ***FY 2014 Plans:*** - Develop five web-based interactive computer simulations based on mapped high-level software specifications and codes. - Launch public web site to attract the widest possible base for crowd-sourcing formal verifications. - Map solutions as code annotations back into formal verification tools and assess the effectiveness of these solutions by verifying the absence of errors on the MITRE Common Weakness Enumeration/SANS Institute Top 25 lists. - Refine initial simulations and develop new simulations for greater verification effectiveness.	6.537	13.182	20.230
Title: Cyber Warfare Control System (CWCS)	0.000	0.000	5.237

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Description: The Cyber Warfare Control System (CWCS) program will create a semi-automated system that can sense and respond to cyber attacks more rapidly than human operators. CWCS will combine fully-automated cyber defense with man-in-the-loop cyber offense to bring to bear the full range of cyber responses allowed under applicable policies. Technologies to be developed and integrated may include anomaly detection, big data analytics, case-based reasoning, heuristics, game theory, and stochastic optimization. The CWCS capability is needed because highly-scripted, distributed cyber attacks exhibit speed, complexity, and scale that exceed the capability of human cyber defenders to respond in a timely manner. A CWCS prototype system should be capable of competing at a high level in cyber competitions. ***FY 2014 Plans:*** - Develop the high-level architecture for a semi-automated/man-in-the-loop cyber warfare control system. - Identify signals exploitable for cyber warfare and develop new instrumentation approaches for obtaining these signals. - Develop a rigorous analytic formulation for cyber warfare using techniques from game theory, stochastic optimization, and other quantitative disciplines.			
Title: Cyber Camouflage, Concealment, and Deception (C3D) ***Description:*** The Cyber Camouflage, Concealment, and Deception (C3D) program is developing 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 Accomplishments:*** - Developed a prototype web application security platform that enables operators to embed simulated vulnerabilities into existing production websites and uses a set of match, action, and report processes to target the activities of malicious insiders. - Coordinated with network security and counter-intelligence personnel about the possibility of a pilot deployment on a particular military network. ***FY 2013 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.	7.596	15.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- 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.			
Accomplishments/Planned Programs Subtotals	24.483	50.000	60.467

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	46.020	30.424	16.330	-	16.330	0.000	0.000	0.000	0.000	Continuing	Continuing
COG-02: *COGNITIVE COMPUTING*	-	11.360	9.542	3.503	-	3.503	0.000	0.000	0.000	0.000	Continuing	Continuing
COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	-	34.660	20.882	12.827	-	12.827	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2014 Defense Advanced Research Projects Agency	DATE: April 2013
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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	49.365	30.424	24.405	-	24.405
Current President's Budget	46.020	30.424	16.330	-	16.330
Total Adjustments	-3.345	0.000	-8.075	-	-8.075
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-2.000	0.000			
• SBIR/STTR Transfer	-1.345	0.000			
• TotalOtherAdjustments	-	-	-8.075	-	-8.075

Change Summary Explanation

FY 2012: Decrease reflects reductions for the SBIR/STTR transfer and internal below threshold reprogrammings.
FY 2014: Decrease reflects completion of the Transformative Apps and Autonomous Robotic Manipulation Programs in FY 2014.

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
COG-02: *COGNITIVE COMPUTING*	-	11.360	9.542	3.503	-	3.503	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

The Cognitive Computing project will develop core technologies that enable computing and autonomy systems to learn and apply knowledge gained through experience. These technologies will lead to systems with increased self-reliance and the capacity to operate with reduced programmer and operator intervention. In resource-limited settings, these capabilities will make the difference between mission success and mission degradation or failure, increase safety by allowing warfighters to operate systems from greater standoff distances, and reduce staffing requirements by providing greater autonomy.

B. Accomplishments/Planned Programs ($ in Millions)

	FY 2012	FY 2013	FY 2014
Title: Autonomous Robotic Manipulation (ARM)	11.360	9.542	3.503
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 2012 Accomplishments:*** - Developed a bi-manual manipulator platform by adding a second arm to the existing manipulator system, and demonstrated operation within a larger workspace and handling of articulated objects such as pliers and scissors. - Developed algorithms that enable head tracking of the task objects to accelerate completion time and increase robustness to change. ***FY 2013 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
- Develop and demonstrate algorithms for autonomous grasping of complex objects, such as the handle of an impact driver. - Develop and demonstrate algorithms for autonomous bimanual manipulation, such as zipping open a satchel bag and extracting an object. ***FY 2014 Plans:*** - Develop robust algorithms that locate and identify objects in various real-world scenarios. - Evaluate all performer autonomous algorithms through a series of experiments.			
Accomplishments/Planned Programs Subtotals	11.360	9.542	3.503

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency			DATE: April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	-	34.660	20.882	12.827	-	12.827	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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. 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 2012	FY 2013	FY 2014
Title: Transformative Apps ***Description:*** Transformative Apps is creating 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 are being 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, are tested in different training environments as well as in deployed environments. Performance and usage are carefully tracked and user feedback collected to guide rapid enhancement of apps. The effort is creating 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. ***FY 2012 Accomplishments:*** - Expanded operational trial in theater to 2,300 users with operational requests for more units. - Conducted evaluation with secure network infrastructure and demonstrated interoperability with military-grade encryption. - Enhanced middleware and services for apps. - Demonstrated apps code screening and vetting processes. - Developed tools enabling non-experts to create apps on smartphone platforms. ***FY 2013 Plans:***	19.471	20.882	12.827

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
- Integrate and test with military tactical radio networks. - Demonstrate interoperability with Army systems on mounted platforms. - Develop the apps certification process and deploy to Army users. - Expand apps library and initiate transition to program of record. ***FY 2014 Plans:*** - Demonstrate full interoperability across dismounted, mounted, and tactical ops center users. - Demonstrate training app suite for CONUS users. - Enhance situational awareness apps for use in CONUS exercises.			
Title: Detection and Computational Analysis of Psychological Signals (DCAPS) - Medical ***Description:*** The Detection and Computational Analysis of Psychological Signals (DCAPS) program is developing automated information systems that identify group and individual trends indicative of post-traumatic stress disorder (PTSD) and traumatic brain injury (TBI) and anomaly detection algorithms that identify emerging physical and psychological crises. These will complement commercial offerings that 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 incorporates strong authentication and other security mechanisms as needed to protect patient data. The program is also developing 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 is funded in PE 0602115E, Biomedical Technology beginning in FY 2013. ***FY 2012 Accomplishments:*** - Completed development of a mobile device psychological health application with integrated privacy safeguards. - Developed additional psychological telehealth applications that integrate multiple psychological health indicators such as so-called "honest signals". - Developed plans for user trials of mobile psychological health and telehealth applications in coordination with transition partners.	8.189	0.000	0.000
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 developed 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 consisted 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 provided automated support for the collect-update-analyze-prioritize	7.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
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 2012 Accomplishments:*** - Enhanced algorithms to address uncertain and dynamic data. - Expanded architecture to support multiple distributed users, as well as disconnected operations. - Evaluated system on real-world data and problems.			
Accomplishments/Planned Programs Subtotals	34.660	20.882	12.827

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	49.717	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
MCN-01: *MACHINE INTELLIGENCE*	-	49.717	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

The Machine Intelligence project developed technologies that 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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	52.276	0.000	0.000	-	0.000
Current President's Budget	49.717	0.000	0.000	-	0.000
Total Adjustments	-2.559	0.000	0.000	-	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.134	0.000			
• SBIR/STTR Transfer	-1.425	0.000			

Change Summary Explanation

FY 2012: Decrease reflects reductions for the SBIR/STTR transfer and internal below threshold reprogrammings.

C. Accomplishments/Planned Programs ($ in Millions)

	FY 2012	FY 2013	FY 2014
Title: Machine Reading and Reasoning Technology ***Description:*** The Machine Reading and Reasoning Technology program developed enabling technologies to acquire, integrate, and use high performance reasoning strategies in knowledge-rich domains. Such technologies provide DoD decision makers with	24.359	0.000	0.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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 were developed to extract key information and metadata, and exploit these via context-capable search and inference. ***FY 2012 Accomplishments:*** - Developed the capability to automatically learn reading patterns by addressing ambiguity resolution and discovering inference patterns. - Demonstrated temporal reasoning over facts and events extracted from text. - Initiated application of 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. This effort is funded in PE 0602702E, Project TT-13 in FY 2013. ***FY 2012 Accomplishments:*** - Developed improved visual intelligence capabilities based on initial assessments and evaluated on operationally relevant datasets. - Integrated visual intelligence into three smart camera prototypes and performed concept demonstration to U.S. Army.	13.441	0.000	0.000
Title: Visual Media Reasoning (VMR) ***Description:*** The Visual Media Reasoning (VMR) program is creating technologies to automate the analysis of enemy-recorded photos and videos and identify, within minutes, key information related to the content. This will include the identification 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 leveraged by a warfighter or analyst attempting to understand a specific new image in a timely fashion. 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 distributed 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 is funded in PE 0602702E, Project TT-13 in FY 2013. ***FY 2012 Accomplishments:***	11.917	0.000	0.000

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
- Created application programming interfaces as the basis for an open architecture that facilitates integrating new computer vision algorithms. - Demonstrated and integrated initial set of biometric, object, and scene description algorithms into a single system. - Identified high priority operational use cases for each of the areas: Who, What, Where and When, using feedback from the warfighter/analyst user group. - Established a collaborative relationship with the National Media Exploitation Center (NMEC) under which VMR researchers accessed a sample comprised of tens of thousands of images and videos from NMEC's large corpus of adversary photos/videos and experimented with a "mini-clone" of NMEC's new NEXSYS multimedia exploitation system.			
Accomplishments/Planned Programs Subtotals	49.717	0.000	0.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	30.844	19.236	24.537	-	24.537	28.825	28.810	38.747	28.206	Continuing	Continuing
BW-01: *BIOLOGICAL WARFARE DEFENSE*	-	30.844	19.236	24.537	-	24.537	28.825	28.810	38.747	28.206	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	30.421	19.236	27.008	-	27.008
Current President's Budget	30.844	19.236	24.537	-	24.537
Total Adjustments	0.423	0.000	-2.471	-	-2.471
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	1.252	0.000			
• SBIR/STTR Transfer	-0.829	0.000			
• TotalOtherAdjustments	-	-	-2.471	-	-2.471

Change Summary Explanation

FY 2012: Increase reflects an internal below threshold reprogramming offset by the SBIR/STTR transfer.
FY 2014: Decrease reflects minor repricing.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
Title: Medical Countermeasures ***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. For example, this program will develop in vitro tissue constructs (IVTC) that will emulate human response to therapeutic compounds, thereby significantly reducing the cost and time for evaluating safety and efficacy of therapeutics. ***FY 2012 Accomplishments:*** - Began development of in vitro tissue constructs (IVTC) that mimic the functions of human physiological systems. - Designed a modular platform able to sustain and monitor IVTC function. - Began 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 two or more IVTCs to recapitulate the function of intact 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. ***FY 2014 Plans:*** - Demonstrate an expanded set of IVTCs able to reproduce the function of four human physiological systems. - Design and build additional modules that are compatible with the expanded set of IVTCs and enable the platform to sustain the integrated IVTCs for 2 weeks. - Demonstrate that the expanded set of IVTCs individually respond and react to test compounds in a manner consistent with the known effects of those compounds on the corresponding human tissues. - Demonstrate that a modular arrangement of the expanded set of IVTCs can be used to predict the kinetics of metabolism and elimination that the test compounds are known to exhibit in human physiological systems.	14.342	19.236	24.537
Title: Unconventional Therapeutics ***Description:*** This thrust developed unique and unconventional approaches to ensure that soldiers are protected against a wide variety of naturally occurring, indigenous or engineered threats. Emphasis was placed on discovery and development of technologies that allow a rapid response (within weeks) to unanticipated threats, whether naturally encountered emerging	10.000	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
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 2012	FY 2013	FY 2014
diseases or agents from intentional attack, to significantly decrease the time needed to produce candidate vaccine. Additionally, new technologies were developed to allow the rapid, cost-effective manufacture of complex therapeutic proteins such as monoclonal antibodies and vaccine antigens; these technologies reduced the time for biologics manufacture from years (or even decades) to only weeks. Select efforts funded under Unconventional Therapeutics transferred to the Medical Program Element 0602115E, in FY 2012. ***FY 2012 Accomplishments:*** - Completed final proof-of-concept demonstrations to produce 1kg of a recombinant H1N1 vaccine candidate protein using large-scale plant-based manufacturing capabilities. - Continued the evaluation of 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. - Continued to 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. - Continued 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 adjuvant. - Continued the development of vaccine candidates that have enhanced immunogenicity.			
Title: Chemical Reconnaissance ***Description:*** The Chemical Reconnaissance program enabled exhaustive, accurate, and economical collection of atmospheric trace constituents to support chemical mapping of urban and military environments. The system demonstrated materials, packaging, and extraction technologies that sample atmospheric impurities with concentrations ranging from 50 parts per trillion to 50 parts per million by volume, from 100 liter-atmospheres of gas, in less than five minutes. The analysis system integrated 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 yielded 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 2012 Accomplishments:*** - Demonstrated prototype automated analysis system with high fidelity and accuracy at high sample rate. - Designed and validated a bench top system to analyze a large number of samples at low cost.	6.502	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Expanded field testing of sampling technology prototypes with transition partners. - Delivered ruggedized sampling technology prototypes and media validated against operation in various climates and CONOPs. - Integrated sample media processing with automated laboratory analysis system.			
Accomplishments/Planned Programs Subtotals	30.844	19.236	24.537

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	202.735	233.209	225.977	-	225.977	236.874	265.869	298.653	305.243	Continuing	Continuing
TT-03: *NAVAL WARFARE TECHNOLOGY*	-	41.877	53.642	33.563	-	33.563	40.392	51.732	61.839	63.255	Continuing	Continuing
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	-	50.304	49.839	47.951	-	47.951	35.609	15.609	45.185	45.185	Continuing	Continuing
TT-06: *ADVANCED TACTICAL TECHNOLOGY*	-	47.023	22.667	33.544	-	33.544	33.330	34.773	50.543	52.443	Continuing	Continuing
TT-07: *AERONAUTICS TECHNOLOGY*	-	23.699	36.106	25.317	-	25.317	34.437	69.437	45.876	47.245	Continuing	Continuing
TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*	-	39.832	70.955	85.602	-	85.602	93.106	94.318	95.210	97.115	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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. 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

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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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.

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 2012**	**FY 2013**	**FY 2014 Base**	**FY 2014 OCO**	**FY 2014 Total**
Previous President's Budget	202.422	233.209	236.851	-	236.851
Current President's Budget	202.735	233.209	225.977	-	225.977
Total Adjustments	0.313	0.000	-10.874	-	-10.874
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	5.830	0.000			
• SBIR/STTR Transfer	-5.517	0.000			
• TotalOtherAdjustments	-	-	-10.874	-	-10.874

Change Summary Explanation

FY 2012: Increase reflects an internal below threshold reprogramming offset by reductions for the SBIR/STTR transfer.

FY 2014: Decrease reflects drawdown of the Naval Warfare Project as the ACTUV program (Anti-Submarine Continuous Trail Unmanned Vessel) enters the final testing phase.

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency			DATE: April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
TT-03: *NAVAL WARFARE TECHNOLOGY*	-	41.877	53.642	33.563	-	33.563	40.392	51.732	61.839	63.255	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV) ***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 craft at theater or global ranges, from forward operating bases, 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 manned ship design constraints 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 2012 Accomplishments:*** - Initiated ACTUV integrated prototype detailed design, fabrication, and demonstration activity. - Conducted incremental demonstrations of ACTUV critical enabling technologies.	27.740	37.400	15.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Commenced development of ACTUV surrogate hardware-in-the-loop system. - Completed 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. ***FY 2014 Plans:*** - Complete ACTUV sensor testing on surrogate platform. - Initiate ACTUV prototype vessel construction. - Integrate software and hardware into the ACTUV platform.			
Title: Arctic Operations ***Description:*** The Arctic Operations initiative is focused on developing technology to assure U.S. capability to achieve situational awareness in the Arctic. 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 continental shelf. This growth in activity will increase the strategic significance of the region, and will drive the need to ensure stability through effective regional monitoring. The extreme environmental conditions of the Arctic may challenge the effectiveness of conventional technology to provide such monitoring. As such, this program seeks to 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:*** - Initiate system studies and subsystem technology assessments for novel under-ice and near-ice surveillance. - Conduct technology assessments and perform technology demonstrations in climactic laboratories. - Conduct Arctic data collections analyses. - Complete initial Arctic surveillance system studies. - Develop canonical datasets including environmental data collections to support future design studies and technology efforts. ***FY 2014 Plans:*** - Conduct Arctic data collections and analysis for initial subsystem validations. - Conduct system and subsystem designs for under-ice maritime awareness. - Initiate system and sub-system designs for near-ice and surface maritime awareness.	0.000	7.675	10.563

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Begin scaling and design studies to understand limits of unique Arctic properties, including clutter, interference, and false contacts. - Demonstrate software functionality and operation in laboratory and scaled field experiments. - Demonstrate sustained autonomous operation in all system operating modes and transitions in a relevant CONUS-based environment. - Complete system environmental assessment for Arctic demonstrations. - Demonstrate sustained component operability and reliability during seasonal environmental variations. - Conduct system effectiveness modeling.			
Title: Upward Falling Payloads (UFP) ***Description:*** The Upward Falling Payloads (UFP) program will develop forward-deployed unmanned distributed systems that can provide non-lethal effects or situational awareness over large maritime areas. The UFP approach centers on pre-deploying deep-ocean nodes years in advance in forward operating areas which can be commanded from standoff to launch to the surface. Advances in miniaturized sensors and processors, the explosive growth in the variety of small unmanned systems, and the advances in autonomy and networking all point toward highly-capable, yet affordable distributed systems. Currently, large numbers of distributed unmanned systems are not utilized in far-forward areas due to logistics and distance, the need for delivery platforms, and the associated latency for insertion. The UFP program will remove this barrier to accelerate large-scale unmanned distributed applications and missions. The presumption is that a wider range of technology options and system solutions will emerge when the barriers to deployment are removed. ***FY 2014 Plans:*** - Conduct system trade studies addressing a range of UFP applications leading to conceptual designs. - Conduct assessments in simulated and real environments to characterize long-range deep sea communications. - Develop conceptual designs for deep sea containment and launch.	0.000	0.000	8.000
Title: Tactically Expandable Maritime Platform (TEMP) ***Description:*** The Tactically Expandable Maritime Platform (TEMP) concept 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	7.000	3.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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 Accomplishments:*** - Completed TEMP HA/DR critical technology risk reduction demonstrations. - Completed TEMP HA/DR preliminary design activity and conducted a preliminary design review. - Completed TEMP Modular Sea Depot autonomy and water docking tests. ***FY 2013 Plans:*** - Conduct TEMP Modular Sea Depot ballast testing and prototype operational demonstration. - Conduct incremental risk reduction testing of TEMP critical enabling technologies, including 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 propulsion concepts to increase operational capability and efficiency of maritime systems, development of standoff technologies for rapid defeat of anti-access mines, and development of new concepts for employment of distributed unmanned systems. ***FY 2012 Accomplishments:*** - Completed assessment of novel maritime propulsion approaches. - Completed assessment of hydroacoustic anti-mine array source technology. - Initiated study of new concepts for employment of distributed unmanned systems with focus on anti-access and area denial challenges. ***FY 2013 Plans:*** - Continue efforts to develop new concepts and capabilities for use of distributed unmanned systems in challenging threat environments including advanced placement of situational awareness systems.	7.137	5.567	0.000
Accomplishments/Planned Programs Subtotals	41.877	53.642	33.563

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	-	50.304	49.839	47.951	-	47.951	35.609	15.609	45.185	45.185	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012**	**FY 2013**	**FY 2014**
Title: Fast, Adaptable, Next Generation Ground Combat Vehicle (FANG)	29.961	30.977	20.000
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 (IFV) to a requirements set loosely analogous to an existing program of record, but executed on a roughly one-year timescale. ***FY 2012 Accomplishments:*** - Prepared competition guidelines and participation outreach for an open collaborative design community. - Completed the development and began operational testing of the collaborative vehicle design environment, with intent for use in design of mobility subsystems and drivetrains for military vehicles. - Prepared notional design requirements for an IFV drivetrain and mobility subsystem. - Completed procurement, development, and deployment of next-generation cloud-based infrastructure for the VehicleFORGE design sharing website. - Completed algorithms and prototype development for next-generation reputation management engine and began simulating FANG challenges with good and malicious users/parts to analyze reputation accumulation and effectiveness.			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Completed alpha prototype for web-based virtual world collaboration environment which allows users to explore component models and assemblies in a rich graphical environment. ***FY 2013 Plans:*** - Perform experimental subsystem designs and subsequent design builds as a "beta test" activity using the vehicle design environment as well as the iFAB Foundry. - Promulgate component model libraries, foundry capabilities, and objective design criteria for the first FANG Challenge covering an IFV drivetrain and mobility subsystem. - Maintain and develop incremental upgrades to the collaborative vehicle design environment. - Conduct the first FANG Challenge, a competitive, collaborative design contest for the drivetrain and mobility subsystem of a heavy, amphibious IFV. - Product check the selected drivetrain and mobility subsystem built by the iFAB Foundry. - Conduct developmental testing and evaluation of the drivetrain and mobility subsystem built by the iFAB Foundry. - Prepare notional design requirements for an IFV chassis and integrated survivability subsystem. - Promulgate component model libraries, foundry capabilities, and objective design criteria for the second FANG Challenge covering an IFV chassis and integrated survivability subsystem. ***FY 2014 Plans:*** - Conduct the second FANG Challenge, a competitive, collaborative design challenge for the chassis and survivability subsystem of a heavy, amphibious IFV. - Maintain and develop incremental upgrades to the collaborative vehicle design environment. - Product check the selected chassis and integrated survivability subsystem built by the iFAB Foundry. - Begin developmental testing and evaluation of the chassis and integrated survivability subsystem. - Prepare notional design requirements for an entire amphibious IFV. - Promulgate component model libraries, foundry capabilities, and objective design criteria for the third FANG Challenge covering an entire amphibious IFV.			
Title: Robotics Challenge ***Description:*** The Robotics Challenge program, originally reported solely under Project NET-01, PE 0603766E, will directly meet Department of Defense strategic needs by developing robotic technology for disaster response operations. This technology will improve the performance of robots that operate in the rough terrain and austere conditions characteristic of disasters, and use vehicles and tools commonly available in populated areas. This technology will work in ways easily understood by subject matter experts untrained in the operation of robots and be governed by intuitive controls that require little training. The program will also meet the global need for resilience against natural disasters and industrial accidents, and increase the resilience of infrastructure against acts of terrorism.	15.447	18.862	17.951

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
The primary goal of the Robotics Challenge program is to develop ground robotic capabilities to execute complex tasks in dangerous, degraded, human-engineered environments. The program will focus on robots that can utilize available human tools, ranging from hand tools to vehicles. The program aims to advance the key robotic technologies of supervised autonomy, mounted mobility, dismounted mobility, dexterity, strength, and platform endurance. Supervised autonomy will be developed to allow robot control by non-expert operators, to lower operator workload, and to allow effective operation despite low fidelity (low bandwidth, high latency, intermittent) communications. Anticipated Service users include the Army, Marines, and Special Forces. ***FY 2012 Accomplishments:*** - Initiated development of specific challenge events, including methodology, metrics, and parameters. ***FY 2013 Plans:*** - Design robot systems and develop algorithms for locomotion and controls. - Conduct the Virtual Robotics Challenge. - Define the DARPA Robotics Challenge Trials event performance and test criteria. ***FY 2014 Plans:*** - Build robot systems. - Develop algorithms for perception, manipulation, and operator interface. - Conduct the DARPA Robotics Challenge Trials. - Define the DARPA Robotics Challenge Finals event performance and test criteria.			
Title: Infantry Squad Systems (IS2) ***Description:*** The U.S. military achieves overmatch against its adversaries via vehicles in all regimes - land, sea and air. This level of overmatch is not enjoyed at the squad to individual dismounted warfighter level, however. The goal of the IS2 program is to leverage advances in real-time situational awareness and mission command; organic three-dimensional dismount mobility; extended range tracking, targeting, and response; and unmanned mobility and perception in order to create a squad that is 10x more mission capable. The concept of overmatch at the squad level includes increased human stand-off, a smaller force density, and adaptive sensing to allow for responses at multiple scales. IS2 will explore advanced wearable force protection, advanced organic squad level direct and indirect trajectory precision weaponry, and advanced single soldier aerial transport approaches and technologies. This end result of the IS2 program is an individual dismount outfitted with sensors, weaponry, and supporting technology to achieve one-on-one overmatch as well as the overall integration of unmanned assets alongside the dismounts to create a new Hybrid Squad unit. ***FY 2014 Plans:***	0.000	0.000	5.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Perform CONOPS and systems architecture trades studies in the areas of unmanned user interfaces, controls, engineering and perception as well as sensors, weaponry and support technology for soldier sensing, targeting and response. - Develop a simulation environment to allow for an overarching iterative design process.			
Title: Medium Caliber Precision Weapons (MCPW) ***Description:*** The Medium Caliber Precision Weapons (MCPW) program will validate the premise that high precision extended range (1-10 km) direct fire medium caliber cannons can enable smaller combat fighting vehicles and advanced shipboard flexible engagement cannons for ground and naval applications. Lethal direct fire overmatch requires larger cannons and larger vehicles to overcome threat armor systems. MCPW will provide a very precise medium caliber capability to neutralize threat combat vehicles with precision vs. penetration. MCPW will enable smaller very capable combat vehicles, changing the ground vehicle requirement for larger vehicles to support larger cannons. The technologies will also support shipboard precision engagement against "go fast boats" and other lower tier naval threats. ***FY 2014 Plans:*** - Conduct systems architecture trades and cost studies. - Initiate design studies of candidate weapons systems.	0.000	0.000	5.000
Title: C-Sniper ***Description:*** Based on promising results obtained under the Crosshairs program, the C-Sniper effort developed the capability to detect and neutralize enemy snipers before they can engage U.S. Forces. The program delivered a field testable prototype suitable for experimentation on a compatible vehicle such as the Stryker. 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. ***FY 2012 Accomplishments:*** - Completed demonstration of fully integrated system capabilities.	4.896	0.000	0.000
Accomplishments/Planned Programs Subtotals	50.304	49.839	47.951

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
TT-06: *ADVANCED TACTICAL TECHNOLOGY*	-	47.023	22.667	33.544	-	33.544	33.330	34.773	50.543	52.443	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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)	FY 2012	FY 2013	FY 2014
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 on 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 additional elements to the array. Excalibur will provide the technology foundation for the defense of next generation airborne platforms, including all aircraft flying at altitudes below 50,000 ft, and against proliferated, deployed, and next-generation man-portable air-defense systems (MANPADS) and more capable air-to-air missiles converted for use as ground-to-air missiles. Excalibur will enable these platforms to fly at lower altitudes and conduct truly persistent, all-weather ground missions, such as reconnaissance despite low-lying cloud cover. Further capabilities may 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,	24.000	5.197	0.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
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 for light-weight, high power fiber-laser based and podded High Energy Laser Countermeasure (HELCM) systems enabling near-term options for low-altitude aircraft self-defense against MANPADS. The vulnerabilities of MANPADS and other surface-to-air missiles, as well as 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 locating extended-altitude MANPADS; and the potential to use high power fiber lasers for long range target identification and tracking. ***FY 2012 Accomplishments:*** - Demonstrated a 2.5 kW coherently-combinable fiber laser amplifier at electrical efficiencies exceeding 30% and with near-perfect beam divergence. - Initiated the development of advanced packaging, power storage and management, and 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. - Initiated 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 the precision (~~milli-radians) required of current Directional Infared Countermeasure (DIRCM) systems. - Established requirements and initiated design of prototype HELCM open architecture subsystems (laser, beam-control, command, threat warning/lase-quality declaration, lightweight pod). - Identified the requirements and developed conceptual designs for a proactive threat warning capability for HELCM systems. - Conducted further lethality testing to assess vulnerability levels and potential HEL counter-countermeasures (CCMs) of various deployed MANPADS seeker technologies. - Prepared plans and logistics for lethality testing to assess vulnerability levels and potential HEL counter-countermeasures (CCMs) of emerging surface-to-air and air-to-air seeker technologies. ***FY 2013 Plans:*** - Develop 2.5 kW wavelength combined pump sources with greater than 90% combining efficiency that can be coupled into a 200 micron /0.15 numerical aperture fiber.			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Complete the development of advanced packaging, power storage and management, and 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 the (~milli-radians) requirement of current DIRCM systems. - Complete the design of prototype HELCM open architecture subsystems (laser, beam-control, command, threat warning/laser-quality declaration, lightweight pod). - Conceptual design study for a proactive threat warning capability for HELCM systems.			
Title: Endurance* ***Description:*** *Previously part of Excalibur The Endurance program will develop technology for pod-mounted lasers to protect a variety of airborne platforms from emerging and legacy EO/IR guided surface-to-air missiles. The focus of the Endurance effort under TT-06 will be on miniaturizing component technologies, developing high-precision target tracking, identification, and lightweight agile beam control to support target engagement. The program will also focus on the phenomenology of laser-target interactions and associated threat vulnerabilities. This program is an early application of technology developed in the Excalibur program. Advanced research for the program is budgeted in PE 0603739E, project MT-15. ***FY 2013 Plans:*** Design of subsystems: - Design a miniaturized, flight-traceable, low-maintenance laser having output beam parameters that are consistent with estimated mission-kill requirements. - Design of a light-weight highly-agile beam director and beam control assemblies that support coarse and fine tracking of dynamic targets, target-identification and target-engagement, and that can accommodate additional functions such as ISR and target designation. - Design of a high-precision coarse to fine-track and target identification subsystem. - Develop test plans for laser effects testing and initiate the acquisition of threat devices or the design of surrogate devices. ***FY 2014 Plans:*** - Fabrication, assembly, and test of miniaturized subsystems. - Complete the acquisition of threat devices and/ or development of surrogate devices for laser effects testing. - Conduct laser effects testing.	0.000	13.470	23.544

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Estimate, verify or validate vulnerabilities of threats to specific laser irradiation.			
Title: International Space Station SPHERES Integrated Research Experiments (InSPIRE)	2.300	4.000	6.500
Description: An outgrowth of the Integrated Sensing and Processing program, the International Space Station SPHERES Integrated Research Experiments (InSPIRE) program will utilize the DARPA-sponsored Synchronized Position, Hold, Engage, and Reorient Experimental Satellites (SPHERES) platform, which has flown onboard the International Space Station (ISS) since May 2006, to perform a series of multi-body formation flight experiments that necessitate a medium-duration zero-gravity environment. The overarching objectives of InSPIRE are twofold: (1) to leverage the human presence in space for rapid, iterative experimentation and design of DoD-relevant space capabilities, and (2) to provide the next generation of scientists and engineers with experience in carrying out meaningful space experimentation economically, over reasonable time scales. InSPIRE will enhance the ability to rapidly mature and insert new technologies into national security space assets. The InSPIRE program will expand on the capabilities developed through SPHERES by developing a SPHERES-II infrastructure, adding arms, manipulator hands, and hard docking ports. InSPIRE will also design a new generation of Spherelets. Spherelets development will test satellite constructs where small satellite modules self-assemble into larger operational space structures, such as telescopes. In addition, the InSPIRE program will continue the SPHERES Zero Robotics Challenge competition among high schools and middle schools across the United States. ***FY 2012 Accomplishments:*** - Conducted preliminary design review and critical design reviews for ExoSPHERES and the Electromagnetic Formation Flight & Power Transfer Experiment. - Conducted NASA ISS safety reviews for ExoSPHERES. - Conducted NASA ISS safety reviews for the Electromagnetic Formation Flight & Power Transfer Experiment. - Completed Zero Robotics competition. - Completed crowd-sourcing challenge. ***FY 2013 Plans:*** - Conduct second Zero Robotics competition. - Upgrade online SPHERES simulation to incorporate addition of vision-based navigation and manipulator arms. - Design manipulator arms and hand for SPHERES. - Design hard docking port for SPHERES. - Develop conceptual design for Spherelet self-assembling satellite. ***FY 2014 Plans:*** - Build manipulator arms and hand for SPHERES. - Build hard docking port for SPHERES.			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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*

B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Continue design of Spherelet self-assembling satellite.			
Title: Full Spectrum Learning ***Description:*** The Full Spectrum Learning program will integrate the findings and discoveries from studies of learning at all levels, e.g., individual, group, societal, to develop an optimal instruction system. The system will incorporate modern technologies, including machine learning and recommender technology, to identify and suggest optimum teaching methods. ***FY 2014 Plans:*** - Develop system of tools to quantify the learning process and increase training efficacy and efficiency. - Utilize sensors for recording of physiologic, environmental, and neurocognitive data. - Develop human/system interfaces with advances in information technology to visualize data and enable feedback. - Create analysis tools to integrate information and output predictions and recommendations. - Improve models to analytically describe and assess trajectory of learning in individuals and groups.	0.000	0.000	3.500
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 is provided for HELLADS testing in Project NET-01, PE 0603766E. The HELLADS laser will be transitioned following testing to a tactical platform for performance demonstration of ground, sea, or airborne precision engagements. ***FY 2012 Accomplishments:*** - Continued the fabrication of the 150 kW laser.	20.723	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Completed planning and preparations to integrate the 150 kW laser with the ground-based demonstrator laser weapon system. - Initiated subsystem testing of the ground-based demonstrator laser weapon system.			
Accomplishments/Planned Programs Subtotals	47.023	22.667	33.544

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency			DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602702E: *TACTICAL TECHNOLOGY*	PROJECT TT-07: *AERONAUTICS TECHNOLOGY*	

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
TT-07: *AERONAUTICS TECHNOLOGY*	-	23.699	36.106	25.317	-	25.317	34.437	69.437	45.876	47.245	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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)

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Transformer (TX) Vehicle	14.700	19.493	4.317
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 2012 Accomplishments:*** - Conducted preliminary design reviews of TX prototype vehicle. - Completed preliminary detailed vehicle designs that meet program measures of performance. - Completed detailed program plans and costs for the remaining phase. - Integrated critical enabling technology development efforts into overall vehicle development. - Conducted component testing, wind tunnel testing, and static propulsion testing, showing feasibility and function of key technology components. - Initiated risk reduction experiments and modeling to validate design performance.			

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APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602702E: *TACTICAL TECHNOLOGY*	PROJECT TT-07: *AERONAUTICS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Tracked traceability of the prototype vehicle to the field vehicle. ***FY 2013 Plans:*** - Finalize analysis, trade studies, and prototype vehicle element designs to meet the program measures of performance. - Conduct powered wind tunnel testing to increase the fidelity of flight control system development and verify vehicle performance simulations, showing feasibility and function of the design. - Conduct key component tests demonstrating feasibility and function. - Conduct component hardware-in-the-loop testing to ensure successful integration of prototype vehicle subsystems. - Conduct critical design review of TX prototype vehicle to ensure it can proceed to fabrication, test, and demonstration. - Prepare test plans for ground and flight test demonstration. ***FY 2014 Plans:*** - Fabricate custom components, acquire powerplant and drivetrain components. - Conduct component testing and static propulsion testing, showing feasibility and function of critical technology components. - Complete development of flight control software to ensure successful flight and ground testing. - Conduct subsystem testing and integration of components into the full scale prototype TX system. - Complete hardware-in-the-loop and software-in-the-loop testing with fully integrated full scale prototype TX system. - Conduct a test readiness review in preparation for ground and test demonstrations of the prototype vehicle.			
Title: Advanced Aeronautics Technologies ***Description:*** The Advanced Aeronautics Technologies program will examine and evaluate aeronautical 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 2012 Accomplishments:*** - Performed modeling of concepts and architectures. - Conducted 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. ***FY 2014 Plans:***	2.000	2.000	2.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Continue testing of enabling technology components. - Initiate conceptual system design. - Develop technology maturation plan and risk reduction strategy.			
Title: Vertical Take-Off and Landing (VTOL) Technology Demonstrator ***Description:*** The Vertical Take-Off and Landing (VTOL) Technology Demonstrator program, an outgrowth of the Mission Adaptive Rotor program, will demonstrate revolutionary improvements in (heavier than air) VTOL air vehicle capabilities and efficiencies through the development of subsystem and component technologies, and aircraft configurations and system integration. The program will lead to ground and flight tests of a technology demonstrator aircraft. Program goals include demonstrating flight speeds in excess of 300 kts, while simultaneously retaining and proving enhanced hover and hot/high operation that are key and unique to VTOL flight. Improvements in aircraft productivity indices that are reflective of meaningful gains in military transport efficiencies of the system will be a key focus of the program. Considerations will include alternative (for example, non-rotary wing) air vehicle configurations that embrace efficient new designs when addressing lift offset, propulsive compounding, and other solution spaces. A strong emphasis will be placed on the development of elegant, multi-functional subsystem technologies that demonstrate net improvements in aircraft efficiencies that will be exemplified on the basis of defined productivity metrics. Additionally, the program will design and demonstrate new concepts of adaptable landing gear to enable operations from irregular landing zones and moving launch/recovery platforms. Furthermore, novel electric power generation, motors, and distributed propulsion systems will also be studied in detail for future VTOL applications, including thrust and control authority augmentation, and power on demand. The VTOL Technology Demonstrator will demonstrate the mission utility of the new technologies to enable previously un-executable missions and new concepts of operation. ***FY 2013 Plans:*** - Conduct concept design studies. ***FY 2014 Plans:*** - Perform complex simulations to baseline expected system level performance and validate the system concept and underlying enabling technologies. - Perform subscale wind tunnel and laboratory testing. - Define software and hardware integration approach and baseline controls necessary for successful air vehicle concept. - Perform preliminary design reviews in support of air vehicle capabilities and flight test definition.	0.000	4.000	10.000
Title: Next Generation Air Dominance Study ***Description:*** The Next Generation Air Dominance study will define the projected threat domains and capability gaps for the 2020-2050 timeframe. DARPA will conduct a study of current air dominance efforts in coordination with the United States Air Force and Navy and explore potential technology developmental areas to ensure the air superiority of the United States in the	0.000	5.000	5.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
future. The study will consider roles of manned and unmanned platforms; the relative performance of alternative integrated system of systems concepts that combine various mixes of capabilities networked together; and the cost effectiveness of alternative balances of platforms and systesms that provide surveillance, command and control, electronic warfare, and weapons functions. Innovative platform concepts for airframe, propulsion, sensors, weapons integration, avionics, and active and passive survivability features will be explored as a central part of the concept definition effort. This effort will also explore the expanded development and use of automated and advanced aerospace engineering design tools, modeling, and simulation in areas that can increase the likelihood of producing more capable products with improved efficiency. Following the initial multi-agency study, DARPA will present technical challenges to Industry to allow them to explore and present potential solutions. Enabling technologies are next generation platforms, advanced networking capabilities, reliable navigation, passive and active defense, electronic attack, area denial, advanced sensors, and cyber technologies. After the study, it is envisioned that high potential prototype programs will emerge to develop technologies for future air dominance. Early planning for future technologies will also help to define the funding baselines for DOD research and development and acquisition programs. This effort will be funded from PE 0602702E, Project TT-07, and from PE 0603286E, Project AIR-01. Under this PE the study will fund concept and technology development efforts. Systems efforts will be funded from AIR-01. ***FY 2013 Plans:*** - Define projected 2020-2050 threat domains and capability gaps. - Identify funded baseline for DoD efforts for R&D. - Identify high value technologies and prototype opportunities. - Out-brief senior leadership on threat picture and high value opportunities. - In-brief Industry and obtain feedback on potential technology opportunities. ***FY 2014 Plans:*** - Initiate technology and prototype developments. - Conduct Technical Interchange Meeting (TIM) to coordinate between development efforts.			
Title: Petrel ***Description:*** The Petrel program will investigate and develop advanced capabilities for the rapid transport of large quantities of cargo and equipment, such as in support of the deployment of a heavy brigade combat team, from CONUS to the battlefield, reducing the deployment timeline for mechanized land forces and critical supplies anywhere in the world to under 7 days at a price point comparable or slightly in excess of conventional sealift. Petrel will fill the niche between conventional airlift and sealift through development of a new transportation mode capable of high speed operation across the surface/air interface over water as well as terrain. Technical approaches for rapid transport across the ocean and movement from the ship to the tactical battlefield will consider traditional and non-traditional aerodynamic and hydrodynamic concepts as well as innovative uses of	0.000	0.000	4.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
existing technologies. Primary technical goals for Petrel are to reduce or eliminate intermodal delays and to achieve a transport efficiency better than $0.1/ton-mi. ***FY 2014 Plans:*** - Conduct studies to refine the operational trade space, define limits of current technology, and inform new technical approaches. - Initiate concept designs focusing on transport efficiency, speed, and producibility. - Investigate component technologies with potential to enable specific concepts, including advanced propulsion and materials. - Explore innovative approaches for significantly increasing lift to drag ratio.			
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 and applications of advanced manufacturing technologies to reduce part counts and improve dynamic behavior. 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. Other advanced technologies are also being studied which could lead to improvements in hover and cruise efficiencies, and the elimination of large, open rotor systems all together. 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 design, test, and 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 facilitate the development of advanced technologies for application to future vertical take-off and landing (VTOL) class platforms capable of high cruise speed and efficient hover, leading to unsurpassed aircraft performance capabilities. ***FY 2012 Accomplishments:*** - Performed systems requirements and mission analyses to quantify operational MAR objective rotor system capabilities. - Initiated planning for sub-scale ground testing of key MAR demonstration rotor technologies. - Completed conceptual, and initiated detailed, design of hardware for fan-in-wing model wind tunnel test article to study an aerodynamic fairing concept for virtual drag reduction. - Procured hardware in support of sub-scale ground testing of MAR demonstration rotor technologies. ***FY 2013 Plans:*** - Conduct simulations and subscale wind tunnel and ground-based testing of key technologies to meet MAR objectives. - Design, and demonstrate active retreating side blowing on full-scale rotor blades at the National Full-Scale Aerodynamics Complex (NFAC) wind tunnel.	6.999	5.613	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Design, simulate and perform tests of robotic landing gear for rotorcraft to enable uneven terrain and enhanced ship based operations. - Conduct simulations, hover tests and force and moment testing of dual plane prop-rotor concept. - Perform analysis and simulations of advanced VTOL configurations including fan-in-wing for sizing studies and military utility analysis. - Perform wind tunnel testing of a fan-in-wing concept to understand the flow field and possibilities of using the fan as an aerodynamic fairing.			
Accomplishments/Planned Programs Subtotals	23.699	36.106	25.317

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency		DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602702E: *TACTICAL TECHNOLOGY*	PROJECT TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*	-	39.832	70.955	85.602	-	85.602	93.106	94.318	95.210	97.115	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Nexus 7	30.605	35.712	34.034
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. Nexus 7 supports emerging military missions using both traditional and non-traditional data sources for those areas of the world and mission sets with limited conventional Intelligence, Surveillance and Reconnaissance. Examples of additional data sources include foreign news, media, and social network data. These non-traditional sources will be integrated with a wide variety of military structured and unstructured data. Nexus 7 will develop quantitative techniques and tools for processing and analyzing these large data sources as a means for understanding relationships between hostile, neutral, and friendly foreign organizations with the United States. ***FY 2012 Accomplishments:*** - Developed techniques for simulation, visualization, inference, and prediction of quantitative indicators of regional stability. - Evaluated tools and techniques on real-world social-cultural-network data. - Provided quick-response reach-back analytic capability to forward command echelons.			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Began transition of a suite of algorithms, software, and tools throughout DoD including Distributed Common Ground System (DCGS)-Army and NSA. ***FY 2013 Plans:*** - Provide additional quick-response reach-back analytic 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 processing timely, relevant information from traditional and non-traditional data streams that may be incomplete and/or inaccurate. - Transition enhanced algorithms, software, and tools throughout DoD including DCGS-Army and NSA. ***FY 2014 Plans:*** - Develop quantitative techniques and tools for processing, analyzing, and visualizing increasingly large volumes of cyber-social data. - Create and deploy analytics for emerging DoD mission areas to Combatant Commands and other U.S. Government agencies. - Transition suite of algorithms, software, and tools throughout DoD including DCGS-Army and NSA.			
Title: XDATA* ***Description:*** *Formerly Network Flow Analytics The XDATA program seeks to develop computational techniques and software tools for analyzing large volumes of data, both semi-structured (e.g., tabular, relational, categorical, meta-data, spreadsheets) and unstructured (e.g., text documents, message traffic). Central challenges to be addressed include a) developing scalable algorithms for processing imperfect data in distributed data stores, and b) creating effective human-computer interaction tools for facilitating rapidly customizable visual reasoning for diverse missions. The program will develop open source software toolkits that enable flexible software development supporting users processing large volumes of data in timelines commensurate with mission workflows of targeted defense applications. An XDATA framework will support minimization of design-to-deployment time of new analytic and visualization technologies on diverse distributed computing platforms, and also accommodate changing problem spaces and collaborative environments. ***FY 2013 Plans:*** - Explore scalable methods for processing vast amounts of incomplete and imperfect data. - Develop a baseline of open source analytics and visualization technologies for large data processing. - Initiate development of a framework for rapid composition of large data processing systems with advanced analytics and visualization for diverse missions and diverse platforms. - Demonstrate proof-of-concept system on sample open source data.	0.000	15.275	25.800

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Engage DoD users for feedback on proof-of-concept prototypes. ***FY 2014 Plans:*** - Complete development of a framework for processing data from diverse sources with advanced analytics and visualization for diverse missions and diverse platforms. - Develop and demonstrate analytic tools on petabyte scale. - Develop adaptive visualization methods for large data for varying users and contexts. - Demonstrate end-to-end systems in transactional problem domains.			
Title: Visual Media Reasoning (VMR)* ***Description:*** *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. This will include the identification 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 in a timely fashion. 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 distributed 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. - Demonstrate an image indexing scheme that enables the efficient search of large image datasets (hundreds of thousands of images). - Continue to refine the core VMR reasoning engine to process and fuse the outputs of scores of heterogeneous computer vision algorithms during a single query. - Demonstrate tactical machine learning on problems such as image search, activity recognition, pattern-of-life analysis, and autonomous navigation. ***FY 2014 Plans:*** - Establish formal Memorandum of Understanding with at least one DoD/IC transition partner. - Optimize the core VMR reasoning engine to make reliable inferences across the Who, What, Where and When domains to produce more accurate answers to user queries.	0.000	15.192	10.768
Title: Probabilistic Programming for Advancing Machine Learning (PPAML)	0.000	0.000	10.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Description: The Probabilistic Programming for Advancing Machine Learning (PPAML) program will create an advanced computer programming capability that greatly facilitates the construction of new machine learning applications in a wide range of domains. This capability would increase the number of people who could effectively contribute, would make experts more productive, and would enable the creation of new tactical applications that are inconceivable given today's tools. The key enabling technology is a new programming paradigm called probabilistic programming that facilitates the management of uncertain information. In this approach, developers will use the power of a modern (probabilistic) programming language to quickly build a generative model of the phenomenon of interest as well as queries of interest, which a compiler will convert into an efficient application. PPAML technologies will be designed for application to a wide range of military domains including ISR exploitation, robotic and autonomous system navigation and control, weather prediction, and medical diagnostics. ***FY 2014 Plans:*** - Design and build the front end of a probabilistic programming system that enables users from a range of skill levels to construct concise but useful models that can be solved effectively. - Design and build the back end of a probabilistic programming system that takes as input expressive models written in a probabilistic programming language, queries, and prior data and produces as output an efficient implementation with predictable performance. - Identify and develop challenge problems from various military domains, including collecting and making available sample data of appropriate size.			
Title: Manned-Unmanned Collaborative Autonomy ***Description:*** Currently most autonomous unmanned systems, from robots for IED operations to sophisticated drones, are actually operated with supervised autonomy with one or more humans "in-the-loop" for every unmanned system. This prevents humans from effectively performing their mission while also directing the operations of unmanned teammates, thereby negating the force multiplication potential of robotics. The Manned-Unmanned Collaborative Autonomy program will develop concepts and implementing software for a truly shared autonomy - human "on-the-loop" - in which multiple unmanned systems can perform missions with minimal guidance from, and limited cognitive interference with, a single human operator in conventional arenas, such as air or ground, as well as atypical environments such as littoral waters. Approaches to develop shared autonomy will build on past successes in a range of efforts, including pilot-on-the-loop simulations under the past DARPA Unmanned Combat Air Rotor (UCAR) and Unmanned Combat Air Vehicle (UCAV) efforts as well as the significant progress made in DARPA's Warfighter Under Stress program. ***FY 2014 Plans:*** - Develop architecture for manned-unmanned collaborative autonomy. - Develop underlying technologies for collaborative autonomy, such as mission planning using commander's intent.	0.000	0.000	5.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Develop a simulation environment in parallel with technology development.			
Title: Mind's Eye* ***Description:*** * Previously funded in PE 0602305E, Project MCN-01. 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 2013 Plans:*** - Develop selected visual intelligence capabilities and integrate in a prototype smart camera system.	0.000	4.776	0.000
Title: Video and Image Retrieval and Analysis Tool (VIRAT) ***Description:*** The Video and Image Retrieval and Analysis Tool (VIRAT) program developed and demonstrated 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 provides 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 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 products of the VIRAT program have been transitioned to the Distributed Common Ground System (DCGS) - Army. ***FY 2012 Accomplishments:*** - Initiated technologies to accommodate stationary, ground-mounted video sources. - Continued development and optimization of technologies to accommodate larger datasets. - Tested and evaluated performance of the system against an experienced analyst's performance. - Completed a second phase of evaluation by Air Force Electronic Systems Center for potential transition into Air Force DCGS. - Executed an Memorandum of Agreement to transition technologies and software to DCGS-A.	4.574	0.000	0.000
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	3.245	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
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. ***FY 2012 Accomplishments:*** - Integrated updated version of the enhanced breadboard targeting optic device. - Completed multiple rounds of live fire testing to optimize bullet configuration. - Updated guidance and control algorithms to support performance metrics. - Held test readiness review in preparation for live fire demonstration. - Completed live fire demonstration of on-board power generation, processor power-up, and software initiation. - Coordinated with potential transition partners across the Services and Special Forces.			
Title: Integrated Crisis Early Warning System (ICEWS) ***Description:*** The Integrated Crisis Early Warning System (ICEWS) program developed and integrated 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 technologies were successfully transitioned to operations at several commands. ***FY 2012 Accomplishments:*** - Created an automated system to parse news reports, identify key stability drivers, and monitor, assess, and forecast de-stabilizing events in near real time. - Transitioned ICEWS components to USSTRATCOM, USPACOM, and USSOUTHCOM.	1.408	0.000	0.000
Accomplishments/Planned Programs Subtotals	39.832	70.955	85.602

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	203.826	166.067	166.654	-	166.654	179.383	193.695	194.814	199.412	Continuing	Continuing
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	113.051	128.444	126.353	-	126.353	128.407	129.338	139.729	143.577	Continuing	Continuing
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	47.379	37.623	40.301	-	40.301	50.976	64.357	55.085	55.835	Continuing	Continuing
MBT-03: *TACTICAL AND STRATEGIC ENERGY TECHNOLOGY*	-	43.396	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 and manufacturing 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 focused on the unique challenges facing the DoD in developing and demonstrating advanced power generation and energy storage technologies. It addressed 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 2012**	**FY 2013**	**FY 2014 Base**	**FY 2014 OCO**	**FY 2014 Total**
Previous President's Budget	219.816	166.067	191.363	-	191.363
Current President's Budget	203.826	166.067	166.654	-	166.654
Total Adjustments	-15.990	0.000	-24.709	-	-24.709
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-9.999	0.000			
• SBIR/STTR Transfer	-5.991	0.000			
• TotalOtherAdjustments	-	-	-24.709	-	-24.709

Change Summary Explanation

FY 2012: Decrease reflects reductions for internal below threshold reprogrammings and the SBIR/STTR transfer.
FY 2014: Decrease reflects completion of selected power and materials efforts.

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

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	113.051	128.444	126.353	-	126.353	128.407	129.338	139.729	143.577	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Materials Processing and Manufacturing ***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. ***FY 2012 Accomplishments:*** - Demonstrated microstructure/property/process relationship needed for overcoming critical defect limitations in carbon fiber performance for structural applications. - Demonstrated carbon fiber with 50% improvement in stiffness over today's state-of-the-art high-strength structural carbon fibers. - Established viability of fiber production process for structural carbon fiber in suitable quantities for small-lot manufacturing. - Developed rapid, robust manufacturing and processing capabilities that resulted in an expanded base of manufacturing, improved performance, reduced production times, and more affordable manufacturing. - Established 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% improvement in strength and 50% 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% increase in key material properties, 50% reduction of cost over baseline, and 50% reduction in time over baseline.	10.015	17.550	18.300

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- 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% reduction in certification time and cost. ***FY 2014 Plans:*** - Validate predictive capability of process models on material properties and microstructure as well as component performance, quality level, and manufacturing effectiveness. - Validate new probabilistic models and uncertainty quantification methodologies for rapid qualification and certification. - Develop and demonstrate manufacturing assessment tools for select new manufacturing technologies. - For additive manufacture of selected components, establish limits on lot size that provide a 50% reduction in cost and time over standard fabrication baselines. - Establish a library of process models and manufacturing data to support model use and improvement.			
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, 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 2012 Accomplishments:*** - Demonstrated that meltless titanium alloy exhibits properties equivalent to the same conventionally processed alloy. - Completed testing of two 24" x 96" x 12" thick multi-material beam manufacturing demonstration articles. - Designed, fabricated, and evaluated 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. - Addressed high-risk aspects of multi-material manufacturing and testing methods to scale-up the manufacturing process to full-scale articles. - Designed, fabricated, and tested half artifact for experimental modal analysis to measure natural frequencies and mode shapes. - Developed plans and test methods to address critical high-risk structural details of the blade connection methods.	11.686	14.000	4.500

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Continued development and initiated verification of the Coupling Software Environment (CSE) to enable strong coupling of the hybrid multi-material rotor (HMMR) domain codes required for time-accurate performance predictions of multi-material rotors. ***FY 2013 Plans:*** - Complete CSE development and verification to enable strong coupling of the HMMR domain codes required for time-accurate performance predictions of multi-material rotors. - Manufacture and evaluate complex structural test specimens demonstrating ability to design robust products with multi-material technology. - Utilize the CSE to develop a design for a scaled multi-material propeller or rotor for testing on a large-scale vehicle. - Design and fabricate representative articles for large-scale propeller or rotor blades for mechanical evaluations. - Develop manufacturing process plans for large-scale vehicle propeller or rotor blades. ***FY 2014 Plans:*** - Deliver large-scale rotor to the Navy for in-water testing and assessment.			
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. In addition, reactive structures that can serve as both structure and explosive will be developed to decrease the weight and increase the performance of munitions. ***FY 2012 Accomplishments:*** - Designed 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. - Finalized the design and test adaptive structural sub-assemblies incorporating tiered negative stiffness structural elements; activities included final design construction and testing of adaptive structural systems. - Completed the development, construction, and testing of an adaptive structural sub-assembly that incorporated mechanical programs of tiered negative stiffness structural elements. - Exploited latest generation laser technology to study high-temperature chemical reactions at room temperature. ***FY 2013 Plans:*** - Demonstrate a lightweight (20lbs) desalination system that provides up to 75gph potable output from seawater with an overall power consumption of less than or equal to 5W/gph.	11.000	18.000	24.374

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- 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. - Conclude study to determine potential to concurrently reduce explosive payload while maintaining blast output. - Complete characterization of load and strain rate effects on modulus of reactive cases as a function of microstructure, case thickness, and load path. - Complete efforts to optimize amorphous metal reactive structure composition and morphology to sustain loads to >100,000 psi and at strain rates >10^3 sec^-1. - Optimize fiber weave reinforcement architecture (3D) to sustain tensile, compressive, and hoop loads to >100.000 psi and at strain rates >10^3 sec^-1. - Optimize composition, architecture, and impedance of fiber reinforcement weave and reactive matrix to "extrude" reactive constituents through reinforcement weave and produce activated, micron reactive particles. ***FY 2014 Plans:*** - Integrate flux, mobility and reactivity process components to validate low-temperature deposition of DoD-relevant thin film coatings that currently require high bulk temperature. - Quantify temporal and spatial stability of reactive species at ambient temperature for a DoD-relevant thin film coating in an integrated deposition system. - Initiate comprehensive local control approach to thin film synthesis. - Integrate fiber-reinforced reactive matrix and high-stiffness amorphous metals into reactive case structure and characterize dynamic mechanical response. - Demonstrate ability to survive penetration into reinforced concrete with a minimal amount of strain deformation. - Demonstrate survivability of impact into reinforced concrete at ballistic velocities. - Demonstrate scalability to low-rate manufacturing scales while maintaining blast enhancement of survivable materials over inert cased charge.			
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 (EFP) threats across the full spectrum of warfighter environments. Included in this thrust are novel topological concepts as well as entirely new structural designs that will afford enhanced protection and functionality, at reduced weight and/or cost. ***FY 2012 Accomplishments:***	24.538	25.573	25.159

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Extended 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). - Continued to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and vehicles. - Conducted 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. - Continued development and 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. - Continued development of ballistic and blast energy management mechanisms and initiated integration with material properties into candidate armor material systems for optimization against specific threats. - Applied high performance armor technologies to maritime platform armor concepts and adapted them for applications where traditional materials would not be appropriate for the operational environment. - Demonstrated laboratory scale synergistic passive and active armor systems for warhead defeat in multi-material configurations within critical size, weight, power, space, and cost constraints. - Optimized advanced armor solutions utilizing the explosive reactive armor and non-explosive reactive armor concepts. Tested, modeled, and simulated 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. - 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. - Initiate effort to identify critical parameters that will permit scaling of subscale ballistic modeling and testing into the regime of military relevance. - Use the validated physics-based models and simulations previously developed to guide the design, development, and fabrication of ballistic and blast armor.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Continue integration of ballistic and blast energy management mechanisms into material systems and incorporate into candidate armor material systems for optimization against specific threats. ***FY 2014 Plans:*** - Integrate material properties and energy management mechanisms into ballistic armor materials optimized for single threat defeat in each regime (bullet, frag, EFP) to meet survivability objectives. - Demonstrate at least 50% enhancement in opaque vehicle ballistic armor performance in each regime (bullet, frag, EFP) for single threats over state-of-the-art fielded designs. - Based on single threat results, conduct study to establish feasibility of achieving 50% enhancement in opaque vehicle ballistic armor performance for multiple threats. - Continue to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and vehicles. - Demonstrate >2x enhancement in energy absorption capability of candidate tactical vehicle floor isolation materials over currently employed materials. - Determine feasibility to reduce effects of localized dynamic loading in an underbody blast event by 50% over state-of-the-art. - Determine feasibility to reduce effects of global impulse in an underbody blast event by 50% over state-of-the-art.			
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 2012 Accomplishments:*** - Transitioned additional Z-MAN prototype technologies (magnets and microspines) to initial Services clients. - Demonstrated a human static load hanging from gecko nanoadhesive on glass and first-demonstration of human climbing on glass using gecko nanoadhesives. - Integrated and demonstrated components of new design tools for accelerating high-quality design of robots by non-experts, including replacing human programming by user-guided evolution of a controller for a novel legged robot. - Created new brass board fabrication methods for producing robots at low cost, including printing components of a walking robot.	20.000	20.598	20.735

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated new control algorithms in simulation that significantly improved performance including mobility algorithms that allowed robots to locomote at least two times more efficiently by virtue of a compliant suspension, and manipulation techniques that operated in confined spaces. - Designed proof-of-concept full robots with higher-performance mobility including bipeds that can walk on rough terrain (specifically up steep stairs), which current platforms cannot, and robots that locomote at speeds at least twice as fast as current platforms (and in the process set the land-speed record for legged robots). - Explored the actuation design space and developed concepts for actuators with optimized power factor, optimized transmission, and minimized modulation loss. ***FY 2013 Plans:*** - Demonstrate that a soldier with operationally relevant equipment (250lb upper limit) can robustly climb 25-foot walls built from diverse materials using gecko nanoadhesive. - Transition additional Z-MAN prototype sets of gecko nanoadhesive to the Services. - Demonstrate low-volume manufacturing capability of gecko nanoadhesive. - Apply novel design tools to reduce design time of robots to include user-guided evolution of structures and controller, and automated morphological design processes. - Apply fabrication methods to produce robot components at substantial (> 50% 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. - Develop high efficiency actuators, e.g., 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. ***FY 2014 Plans:*** - Complete design of actuation system for a humanoid robot, including bench-top testing of high-risk components and/or subsystems. - Demonstrate actuation of a humanoid robot that increases its energy efficiency by 20x, using the same kinematic structure, energy source, computing, and low-level control software. - Demonstrate advanced energy-efficiency improvement actuation approaches by quantitative analysis and/or simulation. - Validate advanced energy-efficiency improvement actuation approaches by experiment.			
Title: Functional Materials and Devices	7.492	10.000	18.985

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Description: The Functional Materials and Devices thrust will address problems with high-performance functional optical materials and components development. Improved materials require deliberate control at the scale of the relevant phenomena. This thrust will leverage the advanced fabrication capabilities currently available, coupled with design of optical materials and component structure, to drive functional materials to high performance for soldier-centric DoD applications by design. Novel optical materials exploiting three-dimensional degrees of freedom to increase wavefront control, and IR emissive materials are examples of materials in which design of structure at the scale of the critical phenomena can have significant impact on their performance. To provide organic information, surveillance, and reconnaissance to the warfighter that greatly enhances awareness, security, and survivability, the capability for wearable (i.e., ultra-low size, weight, and power) systems with specific functionality will be developed. 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 2012 Accomplishments:*** - Fabricated and tested contact lens binocular telescope components enabling hands-free, 2.8x, all-optical zoom, on demand. - Identified potential design options for eventual 10x zoom capability. - Fabricated and tested low profile heads-up display components enabling field of view and resolution comparable to the unaided eye. - Designed wide field of view compact camera that works in conjunction with eye-tracking and head-mounted display to yield low size, weight, and power. ***FY 2013 Plans:*** - Evaluate processes for integrating nano-polarizers with rigid gas permeable contact lenses. - Demonstrate and conduct user testing of 2.8x contact lens binocular telescope. - Demonstrate and conduct user testing of low profile heads-up display components. - Demonstrate wide field of view compact camera components with low size, weight, and power. - Demonstrate software design components supporting the joint optimization of optical and algorithms degrees of freedom. - Demonstrate algorithms for computer-enhanced vision in conjunction with low size, weight, and power micro-cameras. ***FY 2014 Plans:*** - Demonstrate and conduct user testing of 10x hands free zoom capability. - Demonstrate and conduct user testing of fully integrated heads-up display with eye tracking. - Integrate and test of wide field of view compact camera with gaze-following foveation. - Demonstrate integrated software environment for computational imaging.			
Title: Manufacturable Gradient Index Optics (M-GRIN)	12.054	17.223	14.300

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014

Description: 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 long-wave infrared (MWIR and LWIR) applications. A key component of the program is to develop new design tools that enable optics designers to 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 Accomplishments:
- Developed new materials with variable index of refraction (lens tunability).
- Improved materials and designs to reduce size, weight, and/or complexity of optical assemblies for DoD-relevant applications.
- Developed new methods for controlling refractive index in thin layers of infrared (IR)-transparent materials.
- Developed and demonstrated fusion of multiple layers of IR-transparent materials into preforms and characterized their optical performance.
- Developed GRIN design tools with fabrication design rules and manufacturing tolerances.

FY 2013 Plans:
- Design and fabricate tunable lens from variable refractive index materials.
- Establish GRIN exchange to share design tools and build operational framework.
- Design and build prototype IR lenses using previously developed GRIN lens design tools and metrology methods.
- Demonstrate intermediate volume capability with several small lots.
- Demonstrate GRIN design tools for optical design software.

FY 2014 Plans:
- Complete GRIN lens production scale-up and MRL-7/8 consistent with yields of 1-1000 units as well as rapid redevelopment cycles.
- Design and fabricate a GRIN-based optical system to retrofit an existing DoD product or enable a new DoD product with less weight and/or fewer optical elements.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate initial DoD customer interest as measured by orders placed through the GRIN Exchange for custom designed prototypes.			
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 (PV) technologies will strive to meet this need using low cost manufacturing approaches. ***FY 2012 Accomplishments:*** - Demonstrated portable PV devices that produced more than 70% of their specified electrical output after the equivalent of one year of sunlight and after exposure to environmental hazards such as punctures, humidity, and temperature extremes. - Designed portable PV devices that function at greater than 20% power conversion efficiency. - Designed PV devices that have a density of less than 1500 grams per square meter. - Designed portable PV devices that have a maximum radius of curvature of 3 cm. ***FY 2013 Plans:*** - Demonstrate portable PV devices that produce at least 80% of their specified electrical output after the equivalent of one year of sunlight and after exposure to environmental hazards such as punctures, humidity, and temperature extremes. - Demonstrate portable PV devices that function at greater than or equal to 20% power conversion efficiency. - Design 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.	4.173	5.500	0.000
Title: Materials for Initiation and Actuation ***Description:*** The Materials for Initiation and Actuation thrust explored and developed materials for initiation and propagation of mechanical and/or chemical effects. Included efforts were structures for meso-scale, electrically initiated combustion and modulation of flame plasmas using acoustics and electrical fields. In addition, reactive structures that can be used to decrease the weight and increase the performance of munitions will be developed. Efforts under Materials for Initiation and Actuation have been merged under Multifunctional Materials and Structures starting in FY 2013. ***FY 2012 Accomplishments:*** - Identified approaches for scaling up electrostatic and acoustic flame suppression to address fires of 1 m^2, alone and in conjunction with conventional approaches, and determined that they are not currently realizable at this scale. - Demonstrated scalability of fabrication, mechanical properties, and blast performance of high-strength reactive cases to 1kg scale.	5.500	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Initiated study to determine potential to concurrently reduce explosive payload and while maintaining blast output. - Initiated characterization of load and strain rate effects on modulus of reactive cases as a function of microstructure, case thickness and load path. - Initiated efforts to optimize amorphous metal reactive structure composition and morphology to sustain loads to >100ksi and at strain rates >10^3 sec^-1.			
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, was 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 2012 Accomplishments:*** - Demonstrated pre-pilot scale technologies that enable the increase in conversion efficiency of cellulosic materials and validate competitive projected production costs of JP-8 at initial commercial scale implementation (50M gal/yr). - Demonstrated pre-pilot scale technology to enable low cost triglyceride oil from algae and validate competitive projected production costs of JP-8 at initial commercial scale implementation (50M gal/yr). - Identified and validated critical economic drivers in bio-fuels cost models through additional data generation at pre-production operation levels.	6.593	0.000	0.000
Accomplishments/Planned Programs Subtotals	113.051	128.444	126.353

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	47.379	37.623	40.301	-	40.301	50.976	64.357	55.085	55.835	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 cognitive therapeutics, and explore neuroscience technologies.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Neuroscience Technologies	10.827	10.000	8.000
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 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 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 2012 Accomplishments:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Began reconstructing a multi-scale network linked to specific stressors and stress response systems using integrated epigenetics, genetics, quantitative model building, bioinformatics, and computational biology approaches. - Continued 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. - Modulated genes and pathways mediating acute and chronic stress-induced dysfunction in circuits for reward, fear, and habit learning for reduction of stress-related dysfunction in animal models. - Developed and implemented interventions for prevention of stress-induced cognitive dysfunction in animal models of acute and chronic stress. - Expanded studies of stress-related dysfunction to include identifying gene, network and specific brain region dysfunction as it relates to suicide. - Demonstrated quantitative biochemical measurement of the impact of stress in real-time through development of advanced biosensors. ***FY 2013 Plans:*** - Integrate human data on stress genes to determine human stress-related gene networks for targeting interventions. - Translate genes and networks identified in animals to humans using high throughput molecular data from population-based studies. - Determine biomarkers of alertness in active duty personnel with psychological health problems/traumatic brain injury. - Relate clinical and psychological profiles of patients with post-traumatic stress disorder to neural networks, neurochemicals and behavior for biomarker identification. - Develop empirically validated intervention strategies to include stress reduction (exercise, meditation), stress inoculation (video training/hyperrealistic training), and/or pharmacological interventions, while maintaining performance. - Identify objective measures of physical and cognitive states through the application of integrated analytics and advanced computational techniques. ***FY 2014 Plans:*** - Determine genetic, epigenetic, and proteomic changes underlying vulnerability to poor decision making in humans. - Exploit advances in the predictive models of the brain to develop tools and techniques that can improve cognitive performance under stress at both the individual and group level.			
Title: BioDesign ***Description:*** BioDesign 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	6.791	11.023	14.084

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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). This thrust will also develop new high-throughput technologies for monitoring the function of cellular machinery at the molecular level and the response(s) of that machinery to physical, chemical, or biological threats. While conventional approaches typically require decades of research, new high-throughput approaches will permit rapid assessment of the impact of known or unknown threats on identified biomolecules and cell function. ***FY 2012 Accomplishments:*** - Developed genetically encoded locks to create "tamper proof" DNA. - Developed 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 that were intentionally made resistant to antimicrobials. - Develop novel genomic circuits to identify microorganisms that 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. ***FY 2014 Plans:*** - Demonstrate functionality of genomic security technologies in two or more different commercially relevant microbes used for production of biocommodities. - Evaluate high-throughput methods such as mass spectrometry imaging that have the potential to map intracellular proteins. - Utilize mass spectrometry imaging to characterize cellular components and interactions between them that reveal the effects of challenge compounds (e.g., chemical threats) on intracellular machinery.			
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. With its ability to perform complex chemistries, be flexibly programmed through DNA code, scale, adapt to changing environments and self-repair, biology represents one of the most powerful manufacturing platforms known. However, the DoD's ability to harness this platform is rudimentary. Living Foundries seeks to develop the 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 program will enable the rapid and scalable development of previously unattainable technologies and products (i.e., those that cannot be accessed using known, synthetic mechanisms), leveraging biology to solve challenges associated with production of new materials (e.g., flouropolymers, enzymes, lubricants, coatings and materials for harsh environments), novel functions (e.g.,	0.000	10.000	18.217

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014

self-repairing and self-regenerating systems), biological reporting systems, and therapeutics to enable new solutions and enhancements to military needs and capabilities. 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 supply chains vulnerable to political change, targeted attack, or environmental accident.

Research thrusts will focus on the development and demonstration of open technology platforms, or bioproduction pipelines, 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 bio-production systems for novel materials. The result will be an integrated, modular infrastructure across the areas of design, fabrication, debugging, analysis, optimization, and validation -- spanning the entire development life-cycle and enabling the ability to rapidly assess and improve designs. Integrated processes developed in this program will translate into significant performance improvements and cost savings for the production of advanced materials, biological reporting systems, and therapeutics. These technologies will ultimately result in point-of-use, on-demand, customizable, and distributed production of strategic materials and systems. Key to success will be tight coupling of computational design, fabrication of systems, debugging using multiple characterization data types, analysis, and further development such that iterative design and experimentation will be accurate, efficient and controlled. Demonstration platforms will be challenged to build a variety of military-relevant and complex materials and functionalities, such as synthesis of advanced, functional chemicals and polymers (e.g., those tolerant of harsh environments), production of bio-reporting systems, or rapid and dynamic prevention, identification, and repair of 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.
- Begin to standardize fabrication, characterization, and test processes on a common infrastructure to enable modularity and flexibility for design and construction of new systems.
- Begin development of new computational algorithms to perform quality control and evaluate screening data to automatically inform the redesign and optimization of novel biological production systems.
- Begin initial demonstrations of ability to design, build and test materials production pathways that are difficult or impossible to synthesize using known mechanisms.

FY 2014 Plans:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Continue standardization, integration, and automation of the fundamental tools and capabilities developed in PE 0601101E/ TRS-01 into a readily adoptable and adaptable biosystem engineering platform. - Continue demonstrations of ability to design, build and test materials production pathways that are difficult or impossible to synthesize using known mechanisms. - Begin to integrate data streams (using previously developed computation algorithms and software) from fabrication, quality control and characterization tools to provide a comprehensive debugging capability and to enable forward design. - Begin to demonstrate, test, and evaluate the extent of design-build-test cycle compression using integrated platform to engineer new bioproduction systems. - Begin testing ability to rapidly transfer a design to a new chassis/biological system to establish flexibility of the platform and production system.			
Title: Maintaining Combat Performance ***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 2012 Accomplishments:*** - Initiated a limited Food and Drug Administration (FDA) Phase I clinical trial for pharmacokinetics, surrogate-efficiency markers, and tolerance to determine drug safety. - Assisted 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. - Established baseline physiology testing at the MWRCE in support of Phase 2 clinical trials for the prevention of altitude illness. - Coordinated a technical review with major pharmaceutical companies to prepare for commercialization of the rapid altitude and hypoxia acclimatization therapeutics. - Initiated relevant core technology efforts: analysis, design, and/or benchtop testing of subsystems.	10.300	2.500	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Initiated development of human and system performance analytical models (as a baseline) and system performance to assess injury mitigation strategies in a simulation environment. ***FY 2013 Plans:*** - Complete altitude illness prevention clinical trials packet for review by FDA/Center for Drug Evaluation and Research (FDA/CDER). - Complete altitude illness treatment clinical trials packet for review by FDA/CDER. - Transition rapid altitude and hypoxia acclimatization therapeutics and preventives to Defense Threat Reduction Agency/Transformational Medical Technologies (DTRA/TMT). - Transition capabilities 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: 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 2012 Accomplishments:*** - Demonstrated continuous production of universal donor RBCs in a large scale bioreactor perfusion system at densities >30 million cells/ml. - Demonstrated differentiation and maturation of human hematopoietic stem cells to achieve levels of hemoglobin and erythroid lineage commitment markers and enucleation efficiencies approaching 30%. - Developed and integrated novel and efficient downstream processing systems enabling rapid throughput to select and isolate mature RBCs suitable for transfusion. - Demonstrated 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:*** - Demonstrate prototype instrument for commercialized in vitro blood production. - Align with interagency requirements for protection of blood supply and to enable rapid response in emergency scenarios.	4.550	4.100	0.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Expand capability of bioreactor to produce therapeutic blood products beyond packed red blood cells.			
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 2012 Accomplishments:*** - Demonstrated neural control of arms by spinal cord-injured patients. - Demonstrated safety and stability of neural interfaces over multiple month periods. - Supported transition efforts of final limb, components, and refinements required by the Food and Drug Administration (FDA). - Provided clinical data to support FDA submission. - Optimized the sensor configuration and algorithm development of the hand and arm to provide meaningful sensory feedback.	12.200	0.000	0.000
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 was to drive a breakthrough in 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 led to the development of prototype digital imaging threat cueing systems capable of effective detection ranges of 1 km against dismounts, 5 km against stationary vehicles, and 10 km against moving vehicles. Simultaneously, the system surveys 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 2012 Accomplishments:*** - Extended algorithms to handle imagery from Army and Marine Corps system, specifically the Cerberus SCOUT, which generated visible, IR, and radar imagery from mast-mounted systems.	1.450	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Improved algorithms to increase frame rate without dropping frames. - Improved brain machine interface to use wearable dry electroencephalogram (EEG) sensors. - Integrated and package threat warning system prototype. - Performed extended field testing and evaluation at sites selected by Night Vision Lab at Camp Roberts, CA.			
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 pursued an integrated approach to developing an advanced object recognition capability based on the visual pathways in the mammalian brain. Specifically, this program developed 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. The program demonstrated an improvement of four orders of magnitude in energy efficiency compared to state-of-the-art algorithms. To achieve the vision, the program utilized advanced device design, signal processing and mathematical techniques across multiple brain regions to create an electronic neuro-biological (neuromorphic) vision system. ***FY 2012 Accomplishments:*** - Completed Phase 1 algorithm development, hardware system implementation, and physiology data collection. - Conducted Phase 1 test and evaluation. For algorithms, compared 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, assessed degree of fidelity to the mammalian visual system, performance in collecting and processing data, and potential for low-power operation.	1.261	0.000	0.000
Accomplishments/Planned Programs Subtotals	47.379	37.623	40.301

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency			DATE: April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
MBT-03: *TACTICAL AND STRATEGIC ENERGY TECHNOLOGY*	-	43.396	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

This project focused on the unique challenges facing the DoD in developing and demonstrating advanced power generation and energy storage technologies. It addressed 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 investigated 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 included 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)	FY 2012	FY 2013	FY 2014
Title: Tactical Advanced Power (TAP) ***Description:*** The Tactical Advanced Power (TAP) program solved high-risk, mission-critical portable power and energy challenges (approximately 1 kilowatt and below) that are unique to DoD. TAP has provided 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 has deployed fuel cell-enabled small (hand-launched) unmanned aerial vehicles for long-endurance missions (greater than 6 hours). ***FY 2012 Accomplishments:*** - Transitioned deployable long-endurance small, unmanned aerial system to user community.	7.800	0.000	0.000
Title: Vulcan ***Description:*** The goal of the Vulcan program was 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	9.396	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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 Accomplishments:*** - Demonstrated pressure gain combustion in combustor components. - Developed preliminary design of a full scale gas turbine engine with an integrated PGC module. - Completed fabrication and test of final phase II rig demonstration hardware. - Instrumented and demonstrated combustor/turbine interaction rig to verify utility of harnessing pressure gain combustion. - Completed risk reduction testing and demonstrations of key PGC component technologies and subsystems.			
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. Program funding continues in PE 0602716E, Project ELT-01. ***FY 2012 Accomplishments:*** - Developed very high frequency, low-loss power switch technology for implementing large envelope-bandwidth modulators for RF power amplifiers. - Completed initial co-designs 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. - Designed and prototyped preliminary amplifier architectures for highly efficient handling of large peak-to-average ratio RF waveforms for military systems. - Initiated prototype characterization and testing in a laboratory environment. - Demonstrated converter efficiency and losses, including co-designed power amplifiers of many classes and approaches through initial prototype deliverables.	26.200	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Designed low-loss packaging strategies and monolithic integration approaches for most promising amplifier-modulator circuit combinations.			
Accomplishments/Planned Programs Subtotals	43.396	0.000	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	216.102	222.416	243.469	-	243.469	254.104	253.843	245.305	244.425	Continuing	Continuing
ELT-01: *ELECTRONICS TECHNOLOGY*	-	216.102	222.416	243.469	-	243.469	254.104	253.843	245.305	244.425	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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B. Program Change Summary ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014 Base**	**FY 2014 OCO**	**FY 2014 Total**
Previous President's Budget	215.178	222.416	222.218	-	222.218
Current President's Budget	216.102	222.416	243.469	-	243.469
Total Adjustments	0.924	0.000	21.251	-	21.251
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	6.788	0.000			
• SBIR/STTR Transfer	-5.864	0.000			
• TotalOtherAdjustments	-	-	21.251	-	21.251

Change Summary Explanation

FY 2012: Increase reflects internal below threshold reprogrammings offset by reductions for the SBIR/STTR transfer.

FY 2014: Increase reflects expansion of efforts to build true systems on a chip that will dramatically reduce the size, weight and volume for a wide array of DoD systems.

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
Title: Terahertz Electronics	15.667	17.250	15.020
Description: Terahertz Electronics is developing 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 2012 Accomplishments:*** - Continued the development of device and integration technologies to realize compact, high performance electronic circuits operating beyond 0.85 THz. - Developed 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.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated useful output power of a high power amplifier at 0.85 THz and measured integrated circuits with performance above 0.8 THz. ***FY 2013 Plans:*** - Achieve key device and integration technologies to realize compact, high performance electronic circuits operating beyond 1.03 THz. - Complete the development of device and integration technologies to realize compact, high performance electronic circuits operating beyond 0.85 THz. - Complete 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. - Initiate multiple circuit implementations for applications between 0.67 THz and 1.03 THz, including passive structures required for signal handling at sub-mm-wave frequencies. - Develop measurement techniques for verifying circuit capability above 0.85 THz and calibrate these methods in a laboratory environment. - Demonstrate receiver/exciter technology for sensor applications requiring coherent processing. ***FY 2014 Plans:*** - Complete circuit demonstrations between 0.67 THz and 1.03 THz, including high power amplifiers and integrated circuits. - Complete measurements of receiver/exciter technologies above 0.67 THz. - Demonstrate heterodyne detection and sensor capability at THz frequencies.			
Title: Adaptive Radio Frequency Technology (ART) ***Description:*** There is a critical ongoing military need for flexible, affordable, hand-held cognitive military electromagnetic interfaces. 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. The project will remove the separate design tasks needed for each unique RF system, which will dramatically reduce the procurement and sustainment cost of military systems. 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), Radio-Frequency Field-Programmable Gate Arrays (RF-FPGA), and Dynamic Live Active Nulling (DyLAN).	26.622	27.702	26.949

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
FY 2012 Accomplishments: - Completed development of feedback-linearized InP Heterojunction Bipolar Transition (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. - Completed 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 developed an integrated field-effect-transistor switch process in support of these applications. - Completed development of InP high electron mobility transistor material structure with 0.5-m gate lengths and achieved > 10 V FET breakdown voltage. - Continued development of novel signal recognition sensor algorithms and integrated circuits that can achieve >400 times reduction in signal recognition energy as compared to state-of-the-art sensor systems. Demonstrated concepts for signal recognition at the simulation level and initiated plans for realization of these techniques in hardware. - Initiated development of reconfigurable RF circuit (RF-FPGA) technologies capable of adapting in the field to at least five wireless RF standards. Development is proceeding along three thrusts: adaptive component technologies, reconfigurable systems, and computer-aided design. - Demonstrated MEMS-based resonators with world-record frequency quality-factor product for RF channelization. ***FY 2013 Plans:*** - Initiate development of RF signal cancellation concepts which will actively eliminate unwanted signals within a receiver without the need for large and typically static passive filtering. - Demonstrate Highly linear Time Delay Unit (TDU) Monolithic Microwave Integrated Circuit (MMIC) for beam-steering applications in wideband phased arrays. - Demonstrate MEMS-based channelized RF receiver topology for use in high-speed spectrum sensing applications - Continue development of novel signal recognition sensor integrated circuits. Demonstrate initial hardware implementations of developed signal recognition concepts/techniques. - Continue development of reconfigurable RF circuit (RF-FPGA) technologies. ***FY 2014 Plans:*** - Continue development of integrated cancellation circuits for the purpose of RF filter replacement in low-SWaP military radios and signal intelligence platforms. - Demonstrate reconfigurable RF circuit (RF-FPGA) technologies at the component and system levels along with the necessary computer-aided design approaches. - Demonstrate the applicability of one piece of RF hardware for 5 different application spaces, as a prototype of how research can lead the way to life cycle cost reduction.			

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate concepts for signal recognition at the hardware level and initiate plans for transitioning these approaches to relevant DoD systems.			
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 Terahertz (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 2012 Accomplishments:*** - Improved scaling efforts for self-aligned structures with short gate length, novel barrier layers and reduced parasitic elements to achieve additional cutoff frequency performance gains. - Completed transistor performance trade-space analysis to achieve ultra-fast power switching capability. - Continued development of an optimized enhancement mode power switch process to complement the high frequency field effect transistors (FET) process. - Established an integrated process for power switching and Microwave Monolithic Integrated Circuit (MMIC) capability using advanced wide band gap devices. - Increased passive element performance of MMIC process utilizing both enhancement and depletion mode devices. - Initiated development of complex analog and digital monolithically integrated circuits based on next generation gallium nitride transistors and integration processes. ***FY 2013 Plans:*** - Continue development of complex analog and digital monolithically integrated circuits based on next generation gallium nitride transistors and integration processes. - Complete scaling efforts for self-aligned structures with short gate length, novel barrier layers and reduced parasitic elements to achieve additional cutoff frequency performance gains. - Increase the Technology Readiness Level (TRL) of the integrated process for power switching and Microwave Monolithic Integrated Circuit (MMIC) capability using advanced wide band gap devices. - Continue to increase passive element performance of MMIC process utilizing both enhancement and depletion mode devices. ***FY 2014 Plans:*** - Demonstrate monolithic integration of mixed signal and power amplifier circuits.	11.200	10.360	11.870

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Complete final demonstrations of complex analog and digital monolithically integrated circuits based on next generation gallium nitride transistors and integration processes. - Complete final E/D mode transistor scaling for fully self-aligned nitride transistors with full process compatibility.			
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) could 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. In the Applied Research part of this program, 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, and advanced technology development efforts funded in PE 0603739E, Project MT-15. ***FY 2012 Accomplishments:*** - Completed design of advanced heterogeneously-integrated wideband, ultra-high-linearity digital-to-analog converters with in situ silicon enabled calibration and linearization. - Completed design and initiated fabrication of higher complexity new generation of heterogeneously-integrated wideband, ultra-high-linearity analog-to-digital converters with in situ silicon enabled calibration and linearization. - Continued multi-user compound-semiconductor on silicon foundry process, which will ultimately be accessible to the wider defense and commercial integrated circuit design community. Completed fabrication of first multi-project wafer run, and initiated fabrication for second multi-project wafer run. - Initiated design and fabrication of high complexity heterogeneously integrated RF/optoelectronic/mixed signal and circuits, including ultra-low noise lasers, optoelectronic RF signal sources, and imaging array chips. ***FY 2013 Plans:***	15.500	28.100	33.584

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Complete fabrication and testing of advanced heterogeneously-integrated wideband, ultra-high-linearity digital-to-analog converters with in situ silicon enabled calibration and linearization. - Complete fabrication and testing of higher complexity new generation of 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. Complete fabrication of second multi-project wafer run, and initiate and complete fabrication of third and fourth multi-project wafer runs. - Initiate 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 multi-user foundry capability based on developed diverse heterogeneous integration processes. - Continue design and fabrication 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 2014 Plans:*** - Continue 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. - Continue manufacturing, yield and reliability enhancement for multi-user foundry capability based on developed diverse heterogeneous integration processes. - Continue design and fabrication of high complexity heterogeneously integrated RF/optoelectronic/mixed signal and circuits, such as wide band RF transmitters, optoelectronic RF signal sources, and laser radar systems.			
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	12.116	18.201	23.396

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
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 2012 Accomplishments:*** - Demonstrated co-fabrication of clocks and inertial sensors into an all silica package smaller than ten cubic millimeters, leveraging the high-quality factor mechanical properties of this material. - Demonstrated silicon dioxide micro-Hemispherical Resonating Gyro with a frequency mismatch of 6 Hertz. - Demonstrated a compact Nuclear Magnetic Resonance (NMR) gyroscope with scale factor instability below 8.7 ppm Root Mean Square (RMS), better than the program goal of 50 ppm. Demonstrated rotation rates up to 2500 degrees per second, greater than program goal of 500 degrees per second. ***FY 2013 Plans:*** - Develop monolithic microfabrication process to co-integrate clock, accelerometers and gyroscopes into small form factor. - Demonstrate the technique for error correction of an inertial sensor on an integrated calibration stage. - Explore and develop predictive models of error sources for gyroscope and accelerometers. - Identify physical and algorithmic self-calibration techniques to compensate for stability and drift of inertial sensors. - Develop turn-key software and provide extended testing results from an NMR gyroscope. - Demonstrate new algorithmic approaches to improve performance by using complimentary acceleration and rotation measurement techniques. ***FY 2014 Plans:*** - Demonstrate a physical structure and architecture of an inertial sensor capable of near navigation-grade performance. - Demonstrate architecture for co-integrated clock, accelerometers, and gyroscope on a small single platform with a volume of less than ten cubic millimeters. - Use predictive error models for on-chip calibration of gyroscopes and accelerometers. - Explore new physics for chip-scale combinatorial atomic navigator and determine fundamental limits of the microtechnology.			

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Develop architectures and algorithms to enable reduced startup time for atomic 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, spatially coherent X-ray sources 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 techniques 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 from blunt trauma without the injection of a contrast enhancing agent. The radiation dose required for imaging will also be reduced. The Applied Research component of this effort will focus on applying basic research discoveries to the development of a 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 Accomplishments:*** - Developed advanced designs for compact and energy-efficient X-ray sources that are spectrally tunable and have narrow energy width. - Developed a coded array of micro-focused X-ray sources for phase contrast imaging. - Designed and evaluated the performance potential of a short-lifetime photoconductor switched tip-on-post (Spindt) field emitter. - Developed concepts and demonstrated components of a miniaturized wafer-scale electron accelerator and electron storage ring. - Investigated 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. - Demonstrated the feasibility of 50X higher spatial resolution using phase contrast computed tomography (CT) of soft tissues; and achieved 10X increase of the contrast resolution in tissue discrimination. ***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. - Begin fabrication of an advanced hard X-ray source based on a whispering gallery mode resonator with multi-layer reflectivity for confinement and gain.	4.500	9.500	9.450

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Coordinate the development of devices capable of producing synchrotron-quality X-rays by integrating the most successful components (cathodes, accelerators, undulators & lasers) in the program. ***FY 2014 Plans:*** - Demonstrate an advanced hard X-ray source based on a whispering gallery mode resonator with multi-layer reflectivity for confinement and gain. - Demonstrate a flat panel x-ray panel based on coded array of micro-focused X-ray sources for phase contrast imaging. - Successfully demonstrate a compact, low-power device capable of generating phase contrast images.			
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 Accomplishments:*** - Completed initial circuit demonstrations necessary for DoD-relevant high-performance microplasma electronics. - Began microplasma modeling and simulation efforts for development of the modeling and simulation design tools (MSDT). - Completed first prototypes of microplasma electronics required for a complete radiation-hardened RF system. - Demonstrated initial development of a microcavity-plasma-based material capable of passively protecting against high power electromagnetic (microwave) pulses while embedded into complex substrates. - Initiated development of fundamental nonlinear signal processing architectures and circuit concepts for use in demonstration of microscale plasma device (MPD) technology. ***FY 2013 Plans:***	6.390	7.816	8.500

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Verify microplasma modeling simulation results against microscale plasma device measurement results to begin optimization of the microplasma modeling and simulation design tool (MSDT) for commercial development of microplasma-based electronics. - Determine feasibility of light absorption and switching utilizing microscale plasmas. - Begin development of a full microplasma-electronics-based radiation-hardened RF system. - Investigate the use of microscale plasma devices for protection of sensing and imaging systems in extreme environments. - Initial field testing of the passive microcavity metamaterial for high power microwave protection. ***FY 2014 Plans:*** - Complete integration of the simulation efforts into the modeling and simulation design tool (MSDT) for commercial development of microplasma based electronics. - Complete fabrication and begin testing of full microplasma-based radiation-hardened RF system including tunable antenna. - Optimize plasma microcavity material for DoD systems of interest, demonstrating protection from high power electromagnetic radiation. - Demonstrate and test nonlinear signal processing circuit concepts and architectures based on microscale plasma device (MPD) technologies.			
Title: IntraChip Enhanced Cooling (ICECool) ***Description:*** The IntraChip Enhanced Cooling 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:*** - Determine feasibility of implementing advanced thermal management techniques into compact defense electronic systems. - Determine limits of advanced thermal technologies through fundamental studies on intra and interchip cooling. - Initiate efforts to apply intra and interchip cooling as part of the thermal management approach of defense electronic systems. ***FY 2014 Plans:***	0.000	11.000	21.500

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate proof of concept of fundamental building blocks of intrachip thermal management including microfabrication in relevant electronic substrates and preliminary thermofluid results. - Prepare and refine initial thermal models of intrachip cooling to explain and predict experimental results. - Demonstrate benefits to system-level performance and size, weight, power, and cost (SWaPC) through the use of intrachip thermal management technologies.			
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. ***FY 2013 Plans:*** - Achieve a safe in vivo nanoplatform sensor to detect one military-relevant analyte (e.g. glucose) in living cells for one month. - Achieve a safe in vivo nanoplatform therapeutic to reduce a military-relevant pathogen or disease cofactor in living cells by 50%. - Facilitate development of a regulatory approval pathway for diagnostic and therapeutic nanoplatforms. ***FY 2014 Plans:*** - Achieve a safe in vivo nanoplatform sensor to detect two military-relevant analytes (e.g. glucose, pathogen) in a small animal for six months. - Achieve a safe in vivo nanoplatform therapeutic to reduce a military-relevant pathogen or disease cofactor in a small animal by 70%. - Begin to obtain regulatory approval of identified safe and effective diagnostic and therapeutic nanoplatforms.	0.000	5.000	18.500
Title: Pixel Network (PIXNET) for Dynamic Visualization ***Description:*** The Pixel Network for dynamic visualization (PIXNET) program addresses the squad level capability gap for target detection, recognition and identification in all weather and day/night missions. The vision of the program is to offer the warfighter a small and versatile infrared (IR) camera that would be affordable to individual soldiers and provide multiple IR band imagery with fusion capability to take full advantage of different wavelength band phenomenology in a compact single unit. In the future, the availability of the PIXNET camera would enable a peer-to-peer networked system for image sharing within a squad, thereby providing a better common operating picture of the battlefield and significantly enhancing the warfighter's situational	0.000	15.000	22.700

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
understanding. The program aims to develop a low size, weight and power (SWaP), low cost, soldier portable multiband infrared camera that will render real-time single and multiple imagery using thermal and reflective bands. The camera will also provide fused reflective and thermal band imagery on demand. The use of fused imagery in the PIXNET design will allow the soldier to detect camouflaged targets and distinguish targets from decoys. The PIXNET camera will eliminate limitations posed by current capability to detect, recognize and identify targets in low light and no light nighttime operations. The PIXNET program will focus on a significant reduction in SWaP and cost of infrared sensor components to enable portability and ability to deploy widely to all participants in the theater. Low-cost manufacturing of wafer scale IR sensors and coolers will provide a price point that will allow these components to be deployed to each warfighter. The emphasis on a small form-factor will naturally enable new opportunities such as surveillance with small UAVs, rifle sights with multiple bands, vehicle mounted, helmet mounted and handheld surveillance systems. The phenomenology of different infrared wavelengths will be exploited for a target of interest and only chunks of relevant data will be fused by a smart phone android processing platform, thus reducing the data burden and ease of display. The combination of a smart phone and PIXNET camera at the soldier level will enable more effective tactics, techniques and procedures (TTP) over the current capability. The PIXNET program takes advantage of the computing capability of smart phones to process and fuse multicolor images and send them as videos or still images to the warfighter's helmet mounted display via a wireless or wired connection. The smart phone and PIXNET camera integration allows for a strategy to produce low cost imaging system with single band and combined band imagery. PIXNET capability could be further exploited in the future to enable a fully networked system such as the Network Warrior integrated multiple Soldier systems capability with full spectrum image and video sharing. ***FY 2013 Plans:*** - Develop and review IR camera design and overall architecture that will demonstrate digital image data transmission and signal processing via wireless connectivity using an android based platform. - Identify parameters required for multi-color helmet mounted technology for very low SWaP multi-color IR camera. - Initiate novel optics materials and constructs for multi-band IR. - Identify wireless interface protocols for rifles/weapons and helmet displays that are compliant with dismount requirements. - Determine optimum algorithm for image fusion and image data transmission. ***FY 2014 Plans:*** - Refine algorithms to fuse data from thermal and reflective bands with good image registration. - Establish interim small form-factor camera integration and demonstrate connectivity to heads up display and Android based platform.			

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Demonstrate multicolor image acquisition by interim PIXNET camera, data transmission to android platform, image fusion by android platform, and viewing of fused imagery on heads-up display.			
Title: Microscale Power Conversion (MPC) ***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 100 Megahertz (MHz) 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 is funded in PE 0602715E, Project MBT-03. ***FY 2013 Plans:*** - Continue development of very high frequency, low-loss power switch technology for implementing large envelope-bandwidth modulators for RF power amplifiers. - Initiate final co-designs 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. - Design and prototype second generation amplifier architectures for highly efficient handling of large peak-to-average ratio RF waveforms for military systems. - Demonstrate second generation converter efficiency and losses, including co-designed power amplifiers of many classes and approaches in a laboratory environment. - Fabricate low-loss packages and monolithically integrated switches for amplifier-modulator circuits of final selection. ***FY 2014 Plans:*** - Complete very high frequency, low-loss power switch technology for implementing large envelope-bandwidth modulators for RF power amplifiers. - Demonstrate final co-designs 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. - Miniaturize most promising amplifier concepts for transmit module integration feasibility. - Demonstrate second generation converter efficiency and losses, including co-designed power amplifiers of many classes and approaches in a laboratory environment.	0.000	10.000	11.500

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate transmission of relevant military waveforms for electronic warfare applications.			
Title: Arrays at Commercial Timescales (ACT) ***Description:*** Phased arrays are critical system components for high performance military electronics with widespread applications in communications, electronic warfare and radar. The DoD relies heavily on phased arrays to maintain technological superiority in nearly every theater of conflict. The DoD cannot update these high cost specialized arrays at the pace necessary to effectively counter adversarial threats under development using commercial-of-the-shelf components that can undergo technology refresh far more frequently. The Arrays at Commercial Timescales (ACT) program will develop adaptive and standardized digital-at-every-element arrays. The hand designed, static RF beamformers will be replaced with cost effective digital array systems capable of a yearly technology refresh. By doing so, phased arrays will become ubiquitous throughout the DoD, proliferating onto many platforms for which phased arrays had been previously prohibitively expensive to develop or maintain. The basic research component of this program is budgeted under PE 0601101E, Project ES-01. ***FY 2014 Plans:*** - Initiate development of common digital hardware components for phased array elements that can be seamlessly integrated into a wide range of platforms. - Initiate the development of digital array systems with performance capabilities that evolve with Moore's law at commercial time scales. - Initiate the development of electromagnetic (EM) interface elements capable of reconfiguring for various array use cases and operational specifications. - Develop array components that can demonstrate interoperability over a wired or wireless network such that the realized performance is an integrated sum of each individual array's performance. - Demonstrate reconfigurability of EM interface components for various array performance specifications and demonstrate compatibility with common digital back-end.	0.000	0.000	18.000
Title: Efficient Computing and Sensing through Optics (ECSO) ***Description:*** The Efficient Computing and Sensing through Optics program will develop a system of efficient, high-speed optical sources, waveguides, detectors and non-linear elements for parallelized computation in the optical domain. The program will deliver a device capable of low-power optical transforms and convolutions yielding efficient computation orders of magnitude faster than the state of the art. Applications include real-time network security and object identification. ***FY 2014 Plans:*** - Identify architectures scalable to future telecom line rates. - Demonstrate real-time correlation for 8 bits at 40 Gbps.	0.000	0.000	11.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate in-line discrete Fourier Transform at 40 Gbps.			
Title: Micro-coolers for Focal Plane Arrays (MC-FPA) ***Description:*** The Micro-coolers for FPAs program will develop low Size, Weight, Power, and cost (SWaP-C) cryogenic coolers for application in high performance IR cameras. The sensitivity of an IR focal-plane array (FPA) is improved by cooling its detectors to cryogenic temperatures. The disadvantages of state-of-the art Sterling cryo-coolers used for high performance IR FPAs are large size, high power and high cost. On the other hand, thermoelectric (TE) coolers used in low performance IR cameras are relatively small, high power and it is difficult to achieve temperatures below 200 K. To reduce IR camera SWaP-C, innovations in cooler technology are needed. This program will exploit the Joule-Thompson (J-T) cooling principle, in a silicon-based MEMS technology, for making IR FPA coolers with very low SWaP-C. MEMS microfluidics, piezoelectric MEMS, and complementary metal-oxide semiconductor (CMOS) electronics will be used to demonstrate an integrated cold head and compressor, all in a semiconductor chip. Since a J-T cooler works by cooling from gas expansion, the coefficient of performance is expected to be much higher than state-of-the-art TE coolers and significantly smaller than Sterling coolers. The chip-scale J-T cooler will be designed for pressure ratios of 4 or 5 to 1 with high compressor frequency in small volume. The goal of the MC-FPA Program will be to demonstrate cooling down to 150K. The microcoolers chip-scale size will cost less and will be significantly smaller. Once the proof-of-principle is demonstrated, subsequent program effort would focus on transitioning to chip-scale manufacture on 8-12 inch wafers, resulting in cooler costs decreasing to as low as $50. An extended wavelength-range short-wave IR detector will be integrated with a micro-cooler for demonstration of the MC-FPA. The basic research component of this program is budgeted under PE 0601101E, Project ES-01. ***FY 2014 Plans:*** - Develop 640X480 extended shortwave infrared (1-2.4 micrometer cutoff) FPA. - Design a readout integrated circuit for the IR FPA chip. - Demonstrate camera electronics for the FPA with provision for chip-scale micro-cooler.	0.000	0.000	5.000
Title: Quantum Information Science (QIS) ***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. The QIS program is a broad effort addressing the fundamental material science and physics associated with solid-state qubits. The primary technical challenges include loss of information due to quantum decoherence and the practical limitations associated with solid-state devices (operation at cryogenic temperatures, susceptibility to electronic and magnetic noise, limited coupling distance for qubit interactions, etc.). Theoretical efforts in QIS are investigating novel techniques for preserving coherence, distributing quantum entanglement, and	4.700	2.350	0.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
efficiently modeling qubit operation. Complementary experiments are seeking to demonstrate qubits with better coherence properties than existing devices and to implement entangling operations between two or more solid-state qubits. Future technologies utilizing quantum information science could enable ultra-secure communications; faster algorithms for optimization and simulation in logistics, war gaming, and pharmaceutical development; and new methods for image and signal processing in measurement and signature intelligence activities (MASINT). ***FY 2012 Accomplishments:*** - Explored novel materials, noise characteristics and decoherence mitigation strategies for qubits. - Performed detailed theoretical modeling of single and double semiconductor qubits. - Demonstrated entangling operation with two semiconductor qubits and high-fidelity (>99%) readout of qubit states. ***FY 2013 Plans:*** - Improve speed and accuracy of numerical modeling of semiconductor qubit operation. - Perform advanced state tomography on qubits. - Demonstrate interconversion of quantum information between different qubits technologies. - Demonstrate transport of quantum information over microscopic scales.			
Title: Vanishing Programmable Resources (VAPR) ***Description:*** The Vanishing Programmable Resources (VAPR) program will create electronic systems capable of physically disappearing (either in whole or in part) in a controlled, triggerable manner. VAPR will enable a host of previously unrealizable technologies that can be programmed to disappear, are biocompatible, and/or are physically reconfigurable. Applications include sensors for conventional indoor/outdoor environments (buildings, transportation and material), environmental monitoring over large areas, and simplified diagnosis, treatment, and health monitoring in the field. The program will develop and establish an initial set of materials and components along with integration and manufacturing capabilities to undergird a fundamentally new class of electronics defined by their performance and transience. These transient electronics will perform in a manner comparable to Commercial Off-The-Shelf (COTS) systems, but with limited device persistence that can be programmed, adjusted in real-time, triggered, and/or sensitive to the environment. VAPR will provide an initial capability to make transient electronics a deployable technology for the DoD and Nation. Basic research for the VAPR program is being performed in PE 0601101E, TRS-01. To manufacture transient systems at scale will require significant research and development into: higher levels of circuit integration and complexity to realize advanced circuit functionalities; integrated system designs to achieve required function (in modes that offer programmed or triggered transience); integration of novel materials into circuit fabrication processes; and development of new packaging strategies. The efficacy of the technological capability developed through VAPR will be demonstrated through a final test vehicle of a transient sensor system. The goal is to develop a suite of design principles, develop	0.000	0.000	6.500

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
strategies and pathways, process flows, tools and basic components that are readily generalizable and can be leveraged towards the development of many other transient electronics devices ***FY 2014 Plans:*** - Begin development of foundry fabrication of transient electronics with key functions (RF, memory, digital logic, power supply, etc.). - Begin development of increased circuit integration and complexity to implement advanced functionalities. - Begin development of transient sensors and power supply strategies. - Begin development of transient device fabrication approaches. - Begin demonstration of transience modes in test vehicles.			
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 currently the only viable option. Successful development of this technology could 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 2012 Accomplishments:*** - Designed and simulated 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. - Designed and validated a hardware neural system of ~10 billion synapses and ~1 million neurons. - Demonstrated a chip fabrication process and development plan supporting ~10 billion synapses per square centimeter and ~1 million neurons per square centimeter. - Downselected among fabrication processes for complimentary metal-oxide semiconductor (CMOS) and novel synaptic memory to optimize for density and power performance. - Refined design tools and techniques by codifying design rules and component properties and matching them to fabrication and simulation capabilities. - Demonstrated 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.	29.555	12.000	0.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Introduced 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. - Demonstrate functionality of chip performing perception challenge task and benchmark against state-of-the-art algorithms and methods. - Determine scalability of hardware systems and future densities and power consumption for next-generation systems.			
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 2012 Accomplishments:*** - Demonstrated effectiveness of self-healing for several mixed-signal cores, including analog-to-digital converters (ADCs), and microwave/mm-wave power amplifiers, receiver chains and phase-locked loop frequency synthesizers. In each case, performance was significantly enhanced relative to baseline designs without integrated self-healing. - Measured 100% performance yield (relative to 0% for a baseline non-healed design) for a 60 Gigahertz (GHz) fully integrated self-healing 16-QAM transceiver. - Designed integrated radar front-end chip exhibiting a 32 decibel (dB) Channel Pair Cancellation Ratio (CPCR) due to self-healing of channel-channel gain and phase errors. This represents a 35 dB improvement over a typical baseline chip without self-healing. - Demonstrated through simulation increased performance yields of mixed-signal SoCs to greater than ninety-five percent with minimal power and die area overhead for a wideband electronic receiver chain, 3 Gigasamples per second analog-to-digital converter and a 4 Gbps radio-on-a-chip.	10.851	2.670	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Continued the development of a self-healing intellectual property core library for DoD user access and demonstrated self-healing integrated circuit designs leveraging cores from multiple performer teams. - Designed self-healing circuits capable of mitigating the effects of negative-bias temperature instability (NBTI) and hot-carrier injection (HCI) which contribute to long-term circuit aging in deep-submicron CMOS transistors. ***FY 2013 Plans:*** - Continue to integrate previously demonstrated mixed-signal cores into a full self-healing microsystems/SoCs and show self-healing techniques capable of achieving >95% performance yield with <5% power consumption overhead through measurement of a sufficient number of sample die. - Continue to develop global self-healing control at the microsystem/SoC level. - Demonstrate self-healing design strategies to compensate for chip ageing. - 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 2012 Accomplishments:*** - Demonstrated watt-level regime, high power added efficiency (PAE) silicon-based power amplifier (PA) circuits at Q-band frequencies. - Demonstrated linearized transmitter circuits based on high PAE PAs at Q-band frequencies with complex modulated waveforms. - Continued the development of watt-level, high PAE silicon-based PA circuits at W-band frequencies. - Continued the 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.	6.306	7.750	0.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- 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 with complex modulated waveforms.			
Title: Photonically Optimized Embedded Microprocessor (POEM) ***Description:*** Based upon current scaling trends, microprocessor performance is projected to 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. ***FY 2012 Accomplishments:*** - Designed and fabricated electrical and optical components capable of a wavelength-division-multiplexed, complementary metal-oxide semiconductor (CMOS)-compatible, optical link with 80 gigabit/second capacity and a link energy efficiency of 1.5 picojoules per bit of data. - Developed DRAM-compatible modulator, multiplexer, coupler, waveguide, and photodetector devices and associated drivers for low-power, high capacity photonic links. - Designed on-chip photonic network to rapidly re-organize data, improving the execution time and total energy consumption of a matrix transpose operation. ***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 6.7 picojoules 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. - Develop an on-chip, uncooled laser operating at 3% wall plug efficiency. - Identify applications where a cluster of photonically optimized microprocessors is useful and design the cluster architecture and photonic network.	26.000	23.417	0.000
Title: Analog-to-Information (A-to-I) Look-Through ***Description:*** 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	10.500	3.800	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
(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 2012 Accomplishments:*** - Finalized implementation and testing of A-to-I receiver data processing algorithms with focus on improving algorithm robustness against operationally-realistic conditions. - Initiated technology transition plans to transition A-to-I receivers to one or more operationally-focused end user organizations. - Developed and demonstrated through analysis, simulation and measurement, suitable Look-Through transmitter architectures. - Designed, fabricated and characterized in laboratory environment Look-Through transmitter cells and signal combining structures. - Demonstrated in a laboratory environment, using only two cells, the concept of current-summed travelling wave combining in a transmission line, achieving 6 dB of forward gain and 58 dB of reverse wave suppression. This is the first-ever demonstration of this kind and a key "proof-of-concept" for this program. ***FY 2013 Plans:*** - Finalize technology transition plans and transition A-to-I receivers to one or more operationally-focused end user organizations. - Complete design, tape out and characterization in laboratory environment of Look-Through transmitters with high linearity, high power, wide bandwidth and high efficiency. - Demonstrate capability of transmitter cells and associated distributed architectures to be re-programmed to perform distributed receiver-mode functions in order to mitigate electronic fratricide. - Demonstrate the transmitter performance in realistic environments for a DoD system of interest.			
Title: Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) ***Description:*** The Advanced Wide Field of View (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.	8.000	7.500	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
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 project in PE 0603739E, MT-15. This program also includes technologies previously addressed in the Wide Field of View (formerly MultiScale Optical Sensor Array Imaging (MOSAIC)) program. ***FY 2012 Accomplishments:*** - Constructed and demonstrated a compact multiscale 1.3 Gigapixel snapshot imaging system. The camera has a 120 by 60 degree FOV and 38 microradian instantaneous field of view (IFOV). - Completed design of 10 Gigapixel camera with 100 by 60 degree FOV and an IFOV of 20 microradians. ***FY 2013 Plans:*** - Assemble and demonstrate 10 Gigapixel camera for diversity of operating modes, such as region of interest, feature detection and full frame capture.			
Title: Leading Edge Access Program (LEAP) ***Description:*** Most Integrated Circuit (IC) foundries offering leading edge technology are located outside of the United States. The detrimental effects of this trend are twofold: a lack of access to advanced onshore technology accelerates the migration of highly trained circuit designers from the United States; and DoD is faced with fewer trusted domestic foundries despite becoming increasingly reliant on leading edge semiconductor processes for its most critical systems. Research at advanced semiconductor technology nodes is essential for driving future technology developments in both commercial and DoD application spaces. Thus, the objective of the Leading Edge Access Program (LEAP) is to provide university, industry and Government researchers access to state-of-the-art, onshore complementary metal-oxide semiconductor (CMOS) technology to develop advanced IC concepts relevant to DoD problems. Specifically, LEAP will offer onshore foundry access to CMOS technology nodes of 45 nm and below to increase the number of U.S. designers possessing expertise in leading edge CMOS nodes. ***FY 2012 Accomplishments:*** - Developed foundry offerings at 45nm and 32nm CMOS nodes and a special 22 nanometer multiproduct wafer. ***FY 2013 Plans:*** - Develop new foundry offerings at 32nm and 22nm CMOS technologies. - Develop new foundry offerings for 9HP 90 nm Silicon-Germanium (SiGE) BiCMOS technologies.	2.000	3.000	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Investigate support for access to silicon photonics MPW efforts. - Initiate discussions and develop plans for 14nm CMOS and 3-D access.			
Title: High Frequency Integrated Vacuum Electronic (HiFIVE) ***Description:*** The objective of the High Frequency Integrated Vacuum Electronics (HiFIVE) program was to develop and demonstrate new high-performance and low-cost technologies for implementing high-power millimeter-wave sources and components. This program developed 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 were 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 eliminated the limitations associated with the conventional methods for assembly of high-power sources in this frequency range. Advanced research for this program was budgeted in PE 0603739E, Project MT-15. ***FY 2012 Accomplishments:*** - Continued efforts to perform laboratory measurements of performance and validate RF power levels, including advanced driver amplifiers. - Continued fabrication and initial testing of a high-power amplifier prototype device incorporating HiFIVE micro-fabrication technologies into a compact module form factor.	4.540	0.000	0.000
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 was 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 represents 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 provided 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 included 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. ***FY 2012 Accomplishments:*** - Demonstrated 8x8 integrated photonic chip scale array beam forming with path towards a 32x32 array. - Demonstrated better than 10°x10° beam steering with <20 decibel sidelobes.	7.466	0.000	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated a 32x32 integrated photonic chip optical phased array with dynamic beam forming and a path towards a 64x64 array. - Demonstrated sidelobe suppression <20 decibels.			
Title: Compact Mid-Ultraviolet Technology ***Description:*** The goal of the Compact Mid-Ultraviolet Technology (CMUVT) program was to develop compact high-brightness Middle Ultraviolet source and detector technologies based on wide band gap diode structures. This program addressed 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 also addressed solar-blind detectors for missile plume identification. ***FY 2012 Accomplishments:*** - Increased the diameter of high-quality aluminum nitride substrates and ternary templates up to 30mm diameter to enable development of optimized devices. - Demonstrated high wall plug efficiency middle-UV (250-270nm) Light-emitting Diodes (LED) with brightness over 100mW, an improvement of >100x over state-of-the-art at the start of the program. - Demonstrated aluminum gallium nitride semiconductor lasers operating at wavelengths as short as 237nm, a reduction of over 100nm compared to state-of-the-art at the start of the program. - Demonstrated insertion of high-power, high-efficiency UV LEDs into Army Tactical Biological Detector (TAC-BIO) aerosol detection system. TAC-BIO using CMUVT LEDs demonstrated 10x enhancement in signal response per Watt of output power compared to TAC-BIO using commercial off-the-shelf UV LEDs.	14.189	0.000	0.000
Accomplishments/Planned Programs Subtotals	216.102	222.416	243.469

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	94.303	174.316	149.804	-	149.804	184.227	183.422	183.281	183.923	Continuing	Continuing
AIR-01: *ADVANCED AEROSPACE SYSTEMS*	-	94.303	174.316	149.804	-	149.804	184.227	183.422	183.281	183.923	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	98.878	174.316	124.530	-	124.530
Current President's Budget	94.303	174.316	149.804	-	149.804
Total Adjustments	-4.575	0.000	25.274	-	25.274
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.880	0.000			
• SBIR/STTR Transfer	-2.695	0.000			
• TotalOtherAdjustments	-	-	25.274	-	25.274

Change Summary Explanation

FY 2012: Decrease reflects reductions for the SBIR/STTR transfer and internal below threshold reprogrammings.

FY 2014: Increase reflects continuation of Long Range Anti-Ship Missile Demonstration program efforts and expanded research in Hypersonics.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Triple Target Terminator (T3)	31.720	38.500	18.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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 2012 Accomplishments:*** - Conducted hardware-in-the-loop integrated subsystem testing. - Conducted propulsion system ground testing. - Completed fabrication of small form factor radios for network testing and design integration. - Initiated range coordination with Point Mugu Test Range to receive flight test approval. ***FY 2013 Plans:*** - Fabricate and ground test flight test articles. - Obtain final flight test approval from Point Mugu Test Range. - Conduct captive carry test of flight test articles. - Conduct separation and boost tests of flight test articles. - Begin airborne launch demonstrations of test articles against three target types. ***FY 2014 Plans:*** - Complete airborne launch demonstrations of test articles against three target types. - Complete and deliver final test 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, 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 2012 Accomplishments:***	15.500	20.249	26.304

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Conducted system requirements reviews of the unmanned A-10 demonstration aircraft and prototype JTAC kit. - Conducted 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. - Completed government furnished equipment transfer of A-10 aircraft, LITENING Targeting pods, and targeting software. - Secured 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 field testing of Government furnished JTAC targeting software with Service partners. - Perform modifications to unmanned A-10 demonstration aircraft and conduct software and hardware ground testing. - Complete 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. - Conduct flight tests of unmanned A-10 aircraft for preliminary safety evaluations. ***FY 2014 Plans:*** - Perform ground test of A-10 demonstration aircraft vehicle management system, flight controls, and weapons employment architecture. - Conduct flight tests of unmanned A-10 systems and LITENING targeting Pod with advanced datalink capabilities. - Complete hardware/software fabrication and field test of prototype PCAS kit for dismounted JTAC. - Conduct technical readiness review of A-10 systems and JTAC kit. - Prepare for live fire demonstrations of PCAS demonstration system.			
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. ***FY 2012 Accomplishments:***	24.015	39.000	29.500

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Developed integrated hardware-in-the-loop platforms. - Completed missile seeker captive carry testing against surrogate targets. - Held critical design review for long range target sensor. - Completed integrated system detail designs. - Completed weapon data link ground testing. - Commenced fabrication, assembly, integration, and checkout of flight test vehicles for initial incremental test events. ***FY 2013 Plans:*** - 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. - 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. - Modify booster adapter structure which mates standard Mk-114 booster clamp to missile body aft end. - Complete detailed design of new hybrid canister with solid-wall section on forward end and corrugated side panels on aft end. - Analyze shock and fly-out performance for the missile and canister. - Complete minor airframe design modifications for canister fit and internal structure/composite skin strengthened to react to vertical launch loads. ***FY 2014 Plans:*** - Complete missile and canister integration for a surface launched system. - Perform two controlled test vehicle flights from the Vertical Launching System.			
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 2012 Accomplishments:***	3.000	3.000	3.000

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Conducted modeling and simulation of system architectures and scenarios. - Performed 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. ***FY 2014 Plans:*** - Define performance constraints and determine design flexibility. - Validate sub-system performance and conduct sub-system risk reduction testing.			
Title: Integrated Hypersonics (IH)* ***Description:*** *Formerly Hypersonic Technologies The goal of the Integrated Hypersonics (IH) program is to develop, mature, and test next-generation technologies needed for global-range, maneuverable, hypersonic flight at Mach 20 and above for missions ranging from time-critical, survivable transport to conventional prompt global strike. IH seeks technological advances in the areas of: next generation aero-configurations; thermal protection systems and hot structures; adaptive guidance, navigation, and control; enhanced range and data collection methods; and advanced propulsion concepts, including real-time trajectory planning. The IH program is designed to address technical challenges and improve understanding of long-range hypersonic flight through an initial full-scale baseline test of an existing hypersonic test vehicle, followed by a series of subscale flight tests, innovative ground-based testing, expanded modeling and simulation, and advanced analytic methods, culminating in a test flight of a full-scale hypersonic demonstrator. This program will leverage advances made by the previously funded Falcon program. The Integrated Hypersonics (IH) program results are planned for transition to the Air Force. ***FY 2013 Plans:*** - Implement improvements in highly coupled hypersonic toolsets incorporating assessed uncertainties of key technologies from prior flight tests and ground testing. - Refine hypersonic boost glide knowledge base and designs through enhanced developmental testing in the areas of aerodynamics, aerothermodynamics, guidance, navigation and control, instrumentation, vehicle recovery, and propulsion. - Improve high temperature materials base for hypersonic flight and re-entry vehicles applications through improved manufacturing, modeling, and ground based testing. - Improve flight test range asset affordability and mission flexibility including options for large scale telemetry collection. - Initiate focused hypersonic technology development efforts to advance the state-of-the-art in analytic methods, computational modeling and simulation, and ground-based testing of technologies for the future demonstration flight.	0.000	38.000	45.000

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Perform long-lead procurement and sub-system builds and begin assembly, integration, and ground testing of a baseline hypersonic technology test flight vehicle utilizing an existing aeroshell and incorporating refined modeling, toolsets, and design, in preparation for flight test. ***FY 2014 Plans:*** - Complete assembly, integration, and ground testing of a baseline hypersonic technology test flight vehicle. - Complete launch vehicle assembly, integration, and ground testing in preparation for the baseline flight. - Complete baseline flight range planning and range safety activities; and begin procurement of baseline flight test range assets. - Conduct ground-based testing and subscale flight tests to mature next generation aero-configurations thermal protection systems and hot structures; adaptive guidance, navigation, and control; enhanced range and data collection methods; and advanced propulsion technologies. - Develop preliminary design configurations of a full-scale demonstrator incorporating next generation technologies.			
Title: Tactically Exploited Reconnaissance Node (TERN)* ***Description:*** *Formerly VTOL (Vertical Take-Off and Landing) X-Plane The goal of the Tactically Exploited Reconnaissance Node (TERN) is to dramatically advance the aviation capability of smaller, lower-cost ships. The program will demonstrate the technology for launch and recovery of large, medium altitude, long-endurance aircraft capable of providing persistent 24/7 Intelligence, Surveillance, and Reconnaissance (ISR) and strike capabilities at long radius orbits. By extending the ISR/strike radius and simultaneously increasing time on station beyond current capabilities from smaller ships, TERN will enable novel operational concepts including responsive, persistent deep overland ISR/strike without requirement for forward basing. To achieve these goals, the program will create new concepts for aircraft launch and recovery, aircraft logistics and maintenance, and aircraft flight in regimes associated with maritime operating conditions. The program will culminate in a launch and recovery demonstration. Application of TERN technologies and operationally concepts will enable a novel and cost efficient approach for mission sets including ship identification, overland or maritime surveillance, and strike. The anticipated transition partner is the Navy. ***FY 2013 Plans:*** - Perform launch and recover technique evaluations and trade studies. - Perform studies on integration with existing Service systems and systems architectures. - Study aircraft design trades and approaches to best meet performance goals at minimum lifecycle cost. ***FY 2014 Plans:*** - Begin development of simulation and control schemes to achieve high precision approach. - Identify existing aircraft content suitable for reuse and re-purposing for TERN application.	0.000	9.600	18.000

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Identify equipment and interface requirements for ship segment. - Conduct enabling technology, component, and sub-system feasibility trades and experiments.			
Title: Next Generation Air Dominance Study ***Description:*** The Next Generation Air Dominance study will define the projected threat domains and capability gaps for the 2020-2050 timeframe. DARPA will conduct a study of current air dominance efforts in coordination with the United States Air Force and Navy and explore potential technology developmental areas to ensure the air superiority of the United States in the future. The study will consider roles of manned and unmanned platforms; the relative performance of alternative integrated systems concepts that combine various mixes of capabilities networked together; and the cost effectiveness of alternative balances of platforms and systems that provide surveillance, command and control, electronic warfare, and weapons functions. Innovative platform concepts for airframe, propulsion, sensors, weapons integration, avionics, and active and passive survivability features will be explored as a central part of the concept definition effort. This effort will also explore the expanded development and use of automated and advanced aerospace engineering design tools, modeling, and simulation in areas that can increase the likelihood of producing more capable products with improved efficiency. Following the initial multi-agency study, DARPA will present technical challenges to industry to allow them to explore and present potential solutions. Enabling technologies are next generation platforms, advanced networking capabilities, reliable navigation, passive and active defense, electronic attack, area denial, advanced sensors, and cyber technologies. After the study, it is envisioned that high potential prototype programs will emerge to develop technologies for future air dominance. Early planning for future technologies will also help to define the funding baselines for DOD research and development and acquisition programs. This effort is funded from PE 0602702E, Project TT-07, and from PE 0603286E, Project AIR-01. ***FY 2013 Plans:*** - Define projected 2020-2050 threat domains and capability gaps. - Identify funded baselines for DoD efforts for R&D and acquisition. - Identify high value technologies and prototype opportunities. - Out-brief senior leadership on threat picture and high value opportunities. - In-brief industry and obtain feedback on potential technology opportunities. ***FY 2014 Plans:*** - Initiate technology and prototype developments. - Conduct Technical Interchange Meeting (TIM) to coordinate between development efforts.	0.000	5.000	5.000
Title: Integrated Sensor Is Structure (ISIS) ***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	5.000	5.000	5.000

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
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. The ISIS technologies will be made available to the Air Force and other Services. ***FY 2012 Accomplishments:*** - Completed radar panel manufacturing process validation. - Developed power system long-term bench testing. - Completed envelope material seaming process development. - Completed risk reduction plan. ***FY 2013 Plans:*** - Test assembly and electro-mechanics of radar panels on pill structure. - Implement radar risk reduction by testing antenna panels in a system integration laboratory for calibration and metrology. ***FY 2014 Plans:*** - Refine antenna panel design based upon calibration and metrology results. - Incorporate and test panels with radar componentry.			
Title: Vulture ***Description:*** The objective of the Vulture program is to demonstrate the required technology to enable an airborne payload to remain persistently on-station, uninterrupted and unreplenished, for over five years performing strategic and tactical 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 a notional aircraft package. 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 remaining Vulture program will conduct subscale demonstration activities to prove out critical technologies. The anticipated transition partners are the Air Force and Navy. ***FY 2012 Accomplishments:*** - Completed system preliminary design review.	10.000	10.000	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Completed anti-reflective coating trade studies. - Completed solar spectrum analysis. - Initiated solid oxide fuel cell (SOFC) power density and degradation testing. ***FY 2013 Plans:*** - Conduct power subsystem critical design review. - Conduct tests of anti-reflective coatings. - Complete solar array fatigue testing. - Develop engineering ground demonstrator and flight-like ground demonstrator for energy storage system. - Conduct engineering ground demonstration testing. - Conduct flight-like ground demonstration testing. - Generate final report.			
Title: Collaborative Hypersonic Research (CHR) ***Description:*** The Collaborative Hypersonic Research (CHR) program will leverage sub-scale boost-glide hypersonic flight vehicles as risk-reduction activities for full-scale maneuvering flight vehicles envisaged in the Integrated Hypersonics program. CHR will establish a deeper foundation of data and investigate aero/thermal and guidance, navigation and control challenges and establish parametric similarity frameworks and tools. By incrementally tackling key technology areas while updating the modeling and simulation (M&S) capabilities, CHR will provide key information to the conventional prompt global strike and hypersonics communities. ***FY 2013 Plans:*** - Develop baseline designs sub-scale boost-glide hypersonic flight test vehicles. - Develop a parametric similarity framework to generalize sub-scale flight results to a wide spectrum of hypersonic vehicle designs. - Evaluate plans for sub-scale flight testing to support full-scale hypersonics development activities. - Assess launch vehicle and range options across the Services and international partners.	0.000	5.967	0.000
Title: Autonomous High Altitude Long Endurance (HALE) Refueling (AHR) ***Description:*** The Autonomous High Altitude Long Endurance (HALE) Refueling (AHR) program demonstrated high altitude refueling capabilities between unmanned aircraft. The program used two 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 vital to manned military aviation. Specific challenges included precise control of limited flight performance aircraft under high-altitude conditions, redundant safe separation, and complex unmanned flight operations. The program also promoted the	5.068	0.000	0.000

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
application of autonomy for better effectiveness, efficiency, and safety in challenging environments. The anticipated transition partners are the Air Force and Navy. ***FY 2012 Accomplishments:*** - Completed aircraft component installations and software validation. - Conducted flight tests and demonstrated key capabilities for refueling. - Conducted aerial refueling close formation flight demonstration. - Completed data analysis and documented autonomous aerial refueling lessons learned.			
Accomplishments/Planned Programs Subtotals	94.303	174.316	149.804

D. Other Program Funding Summary ($ in Millions)

Line Item	FY 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
• Integrated Sensor Is Structure: *Air Force PE 0305205F Project 675372F*	45.900	21.000	8.000		8.000	0.000	0.000	0.000	0.000	Continuing	Continuing
• Integrated Sensor Is Structure:: *Air Force PE 0603203F Project 665A*	3.200	0.000	0.000		0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
• LRASM: *Navy*	25.500	0.000	0.000		0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
• Triple Target Terminator (T3): *Air Force*	27.050	41.730	0.000		0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

Remarks

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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	99.138	159.704	172.546	-	172.546	169.757	169.796	169.186	170.186	Continuing	Continuing
SPC-01: *SPACE PROGRAMS AND TECHNOLOGY*	-	99.138	159.704	172.546	-	172.546	169.757	169.796	169.186	170.186	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 threats, a proliferation of assets to provide robustness against attack, ready access to space, and a flexible infrastructure for maintaining the capabilities of on-orbit assets. Ready access to space requires the delivery of defensive systems, replenishment supplies to orbit, and rapid manufacturing of affordable space capabilities. 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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	97.541	159.704	232.546	-	232.546
Current President's Budget	99.138	159.704	172.546	-	172.546
Total Adjustments	1.597	0.000	-60.000	-	-60.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	4.255	0.000			
• SBIR/STTR Transfer	-2.658	0.000			
• TotalOtherAdjustments	-	-	-60.000	-	-60.000

Change Summary Explanation

FY 2012: Increase reflects internal below threshold reprogrammings offset by the SBIR/STTR transfer.

FY 2014: Decrease reflects rephasing of the major systems efforts in this PE.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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, 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	40.000	48.000	50.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014

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 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 (FDK). 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 communication 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 2012 Accomplishments:
- Completed parametric model analyses of wireless intermodule communications and cluster flight.
- Completed and demonstrated prototype wireless transceivers.
- Completed prototype of design tool for adaptable fractionated space systems.
- Commenced development of the F6TP.
- Performed hardware-in-the-loop testing of the persistent broadband terrestrial connectivity solution via commercial communications relay for LEO fractionated clusters.
- Conducted critical design review (CDR) for the persistent broadband terrestrial connectivity solution for LEO fractionated clusters.

FY 2013 Plans:
- Complete initial version of FDK software and demonstrate functionality in representative orbital conditions.
- Complete initial release of the FDK.
- Complete a fully-functional, polished, well-documented, user-friendly value-centric architecture and design tools for adaptable fractionated space systems.
- Conduct preliminary design review (PDR) for the F6TP.
- Conduct CDR for the F6TP.

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Take delivery of the F6TP breadboards. - Purchase flight units of the F6TPs. - Take delivery of flight unit of the persistent broadband terrestrial connectivity terminal for LEO fractionated clusters. - Initiate development of spacecraft buses and payloads for on-orbit demonstration testbed. - Initiate development of mission operations center. - Initiate launch vehicle procurement. ***FY 2014 Plans:*** - Take delivery of F6TP engineering development units. - Conduct PDR and CDR for the on-orbit demonstration testbed. - Integrate flight unit of the persistent broadband terrestrial connectivity terminal into on-orbit demonstration spacecraft bus. - Integrate wireless transceivers flight units into on-orbit demonstration spacecraft buses. - Integrate mission payload and shared payloads into on-orbit demonstration spacecraft buses.			
Title: Airborne Launch Assist Space Access (ALASA) ***Description:*** 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 per flight of $1 million, including range support costs, to deploy satellites on the order of 100 lb. The anticipated transition partners are the Air Force and Army. ***FY 2012 Accomplishments:*** - Performed conceptual design of selected architecture focusing on key technology and affordability gaps. - Initiated preliminary design. - Developed and matured enabling and enhancing technologies including automatic flight termination systems, advanced rocket engine and pump manufacturing, and rapid mission planning tools. ***FY 2013 Plans:*** - Complete initial test plans for flight demonstrator.	12.000	29.000	40.000

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C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- 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. - Integrate selected enabling and enhancing technologies on launch assist aircraft. ***FY 2014 Plans:*** - Conduct trade studies of additional enabling technology to include propellants, manufacturing, mission planning and range support software, and tracking and flight termination software. - Conduct critical design review of demonstration system and develop flight demonstrator. - Complete ALASA vehicle flight readiness review. - Conduct flight tests. - Establish and publish open standards for interface specifications between launch assist aircraft and launch vehicle. - Initiate demonstration of ALASA vehicle launches.			
Title: Space Domain Awareness (SDA) ***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 resources. 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. 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 collection and data processing/ fusion to provide automated data synergy. The resulting increase in space domain awareness will enhance overall space safety of flight, and allow space operators to make informed, timely decisions. 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.	18.000	29.000	18.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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 non-traditional sources, such as amateur includes orbit outlook astronomers, to evaluation of sparse aperture imaging techniques. The Galileo 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 dispersion within the fiber to properly interfere the light from the two telescopes, precisely measuring the distance between the fixed and mobile telescope systems, and accurately measuring relative phase from low signal flux levels with low mutual coherence. The potential transition customer is the Air Force. ***FY 2012 Accomplishments:*** - Completed intensity correlation imaging study. - Initiated Galileo sparse aperture imaging technology development. - Initiated studies of market-based methods of acquiring SSA data from non-traditional sources. ***FY 2013 Plans:*** - Develop architecture for low cost space situational awareness (SSA) data sources. - Expand the concept of dynamically tasked sensors so that the entire SSA network is continuously optimized and capable of rapid response to any space anomaly or threat. - Develop requirements and complete 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 2014 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 visual magnitude GEO satellite.			
Title: Space Surveillance Telescope (SST)	10.041	10.204	8.000

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014

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 program is also 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. The Air Force Space Command is the intended transition partner.

In addition, the program is investigating 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 data fusion effort is investigating methods which combine observations from disparate sensors (such as optical and radar installations) to more rapidly, accurately, and completely provide knowledge about UCTs. Specifically, the data fusion effort is investigating methods to quickly provide positive identification of orbital objects, rapidly characterize them and maintain a catalog of determined characteristics, and dynamically schedule available sensors to provide the most valuable and timely observations possible. Where appropriate, SST will investigate new concepts which would provide complementary or further advances in ground-based deep space object detection and characterization.

The SST Australia effort will provide a further operational demonstration of the SST at an Australian site. Such a location presents a more operationally relevant demonstration, with a richer and more interesting population of SSA targets in geosynchronous orbit. A demonstration in Australia would investigate telescope performance and observe objects and orbits not visible from the current site in New Mexico. In addition, the demonstration would generate data for analysis and fusion efforts, which will be used to further refine and evaluate data processing techniques, such as those developed under the Ibex effort. This program will address technical challenges which may arise from an Australian site, including adaptations to a different telescope environment, and the logistical and communications challenges presented by a site significantly more remote than the current SST location.

FY 2012 Accomplishments:
- Completed final technical demonstration of SST system performance; evaluated demonstration activities and SST mission functionality.
- Conducted systems requirement review for the data fusion effort.
- Conducted preliminary and critical design reviews for the data fusion effort.
- Developed initial data fusion capability packages.

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	**R-1 ITEM NOMENCLATURE** PE 0603287E: *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Completed initial data fusion demonstration. - Conducted preliminary investigation of locating the SST in more operationally relevant location in Australia in order to perform a more in-depth demonstration. - Completed data acquisition for military utility analysis. ***FY 2013 Plans:*** - Transition data fusion services to users. - Complete military utility assessment of SST. - Complete investigation and planning for optimal SST location in Australia. - Complete SST relocation plan. - Complete evaluation of operational strategies, technology studies, and hardware demonstrations in order to optimize SST performance at Australia site. ***FY 2014 Plans:*** - Disassemble SST in New Mexico. - Ship SST to Australian site and begin integration.			
Title: Phoenix ***Description:*** 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 Geosynchronous (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 and going beyond pure traditional servicing functions. 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 ride-along capability to send newly developed small, modular, and inexpensive "satlet" satellite modules 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 Air Force. ***FY 2012 Accomplishments:*** - Performed conceptual mission design and feasibility studies for a repurposing mission in GEO. - Performed conceptual design of a selected demonstration mission, focusing on system architecture and key technology gaps, with candidates that would support aperture repurposing.	14.097	28.000	40.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	R-1 ITEM NOMENCLATURE PE 0603287E: *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Started technology exploration in redefining the morphology of satellites with satlets, to allow expansion of repurposing precepts at cost points that are orders of magnitude lower than new systems. - Developed initial conceptual design and conducted evaluation of commercial hosted ride-along payloads ability to be ejected safely and securely at GEO to increase tempo of mass to orbit to support satlet architecture. - Developed comprehensive concepts of operations for a one year circumnavigation of the GEO belt with up to two separate repurposed apertures. ***FY 2013 Plans:*** - Complete preliminary design of robotic servicing payload architecture and systems for Phoenix vehicle. - Develop payload orbital delivery systems (PODS) designs for commercial satellite ride-along and show first working prototype for dispensement. - Initiate flight scale build of first satlets and demonstrate aggregation of performance functions in a ground testbed. - Initiate development and build of robotic servicing components including tools and toolbelt systems and select a complete complement of tools for Phoenix. - Initiate six degree of freedom testbed on ground; begin virtual system testing with the primary and secondary robotic arms. - Initiate telepresence simulation and begin to test qualification and training standards for Phoenix robotic operations. - Build first prototype of sensor suite for guidance and control on servicer and evaluate it with actual flight software algorithms. ***FY 2014 Plans:*** - Complete critical design of robotic servicing system including primary and secondary robotic arms and toolbelt. - Deliver sensor suite for guidance and control on servicer. - Deliver primary and secondary robotic hardware and software. - Deliver flight rated PODS for initial integration into a GEO communications satellite. - Deliver a full complement of satlet hardware to support first repurposing aperture. - Deliver repurposing equipment prototypes. - Complete mission validation testing inside a six degree of freedom chamber.			
Title: SeeMe ***Description:*** The Army, 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 (aircraft-released) 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, and reconnaissance system suitable to	5.000	15.500	10.546

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	R-1 ITEM NOMENCLATURE PE 0603287E: *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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 through new satellite manufacturing techniques, advanced low-cost aperture technologies, leveraging alternative launch concepts, and a novel direct-to-user command and data exfiltration architecture. The anticipated transition partners are the Air Force and the Army. ***FY 2012 Accomplishments:*** - Conducted trade study of available technologies and investment opportunities. - Initiated concept design. - Performed detailed system trade between a low cost launch alternative and metrics associated with constellation size and altitude. - Evaluated technologies for direct satellite to handheld device capabilities. - Performed evaluation of a multitude of manufacturing processes and technologies from non-aerospace disciplines to achieve 10x cost reduction. - Selected specific satellite architecture for hardware instantiation as prototypes. ***FY 2013 Plans:*** - Execute technical prototype integration options for hardware level development. - Demonstrate applicability to commercial production environment using commercial off the shelf (COTS) based hardware. - Verify radio frequency and optical aperture template and begin prototype construction. - Complete ground user hardware interface study/development. ***FY 2014 Plans:*** - Prepare critical design of system hardware and software for the satellites to include the payload operations for a handheld communications device. - Complete prototype hardware field demonstration to handheld devices. - Deliver "plan and shoot" software and packaging for the onboard satellites. - Complete and environmentally test initial production run of at least six units to verify the ability to build units within 90 days with no pre-purchased components.			
Title: Experimental Solar Electric Propulsion Vehicle (X-SEP) ***Description:*** The X-SEP program will mature the technologies for advanced solar electric propulsion to support a wide range of future DOD missions. Past DOD and NASA efforts have identified and begun maturing critical enabling technologies including light weight and high power solar arrays, advanced solar cells, efficient deployment mechanisms, power management and distribution; and advanced electric propulsion concepts. A critically important technology gap is integration into a flight	0.000	0.000	2.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	R-1 ITEM NOMENCLATURE PE 0603287E: *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
demonstration able to survive in the harsh radiation and thermal space environments. The X-SEP program will mature and validate key technologies on the ground, then fabricate a deep space X-Satellite to demonstrate: 1) a space qualified power system 1/3 the weight of anything ever flown 2) electric propulsion thrust over input power greater than 90 mN/KW, and 3) modular power scaleable to over 1 MW. A key goal is validating the critical technologies for a wide range of next generation high power space systems including highly survivable early missile warning sensors; space situational awareness; efficient on-orbit robotic servicing; new technical approaches for space based radar; next generation high power communications; and dynamic near continuous maneuvering for survivable information, surveillance and reconnaissance (ISR) orbital missions. The anticipated transition partner is the Air Force with potential follow-on transitions to NASA and/or the commercial sector. ***FY 2014 Plans:*** - Conduct system requirements studies for alternative configurations and to determine operational requirements.			
Title: Small Responsive Space Access X-Plane ***Description:*** The Small Responsive Space Access X-Plane program will mature the technologies and operations for low cost, persistent and responsive space access and global reach. Past efforts have identified and demonstrated critical enabling technologies including composite or light weight structures, propellant tanks, thermal protection systems, rocket propulsion and advanced avionics/software. A critically important technology gap is integration into a flight demonstration able to deliver aircraft-like operability. The program will validate key technologies on the ground, and then fabricate an X-Plane to demonstrate: 1) 10 flights in 10 days, 2) Mach 10+ flight, and 3) 10X lower cost space access for cargoes up to 5,000 lbs to low earth orbit. A key goal is validating the critical technologies for a wide range of next generation high speed aircraft enabling new military capabilities including worldwide reconnaissance, global transport, small responsive space access aircraft and affordable spacelift. The anticipated transition partners are the Air Force, Navy and/or commercial sector. ***FY 2014 Plans:*** - Perform system level trade studies to identify alternative configurations and define tradespace.	0.000	0.000	4.000
Accomplishments/Planned Programs Subtotals	99.138	159.704	172.546

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	144.047	111.008	117.080	-	117.080	159.229	168.112	170.163	175.601	Continuing	Continuing
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	-	55.380	41.466	30.225	-	30.225	29.386	23.642	22.095	20.095	Continuing	Continuing
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	88.667	69.542	86.855	-	86.855	129.843	144.470	148.068	155.506	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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*

B. Program Change Summary ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014 Base**	**FY 2014 OCO**	**FY 2014 Total**
Previous President's Budget	150.286	111.008	104.665	-	104.665
Current President's Budget	144.047	111.008	117.080	-	117.080
Total Adjustments	-6.239	0.000	12.415	-	12.415
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-2.143	0.000			
• SBIR/STTR Transfer	-4.096	0.000			
• TotalOtherAdjustments	-	-	12.415	-	12.415

Change Summary Explanation

FY 2012: Decrease reflects reductions for internal below threshold reprogrammings and the SBIR/STTR transfer.

FY 2014: Increase reflects expansion of laser and maskless lithography work in Project MT-15.

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency			DATE: April 2013
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*	

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	-	55.380	41.466	30.225	-	30.225	29.386	23.642	22.095	20.095	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)	41.989	41.466	30.225
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			

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014

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, Navigation 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 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 2012 Accomplishments:
- Fabricated, for the first time, millimeter-sized 3D structures - spheres, toroids, and "wineglasses" - the structures to enable low-cost, small size rate integrating gyroscopes; the design paradigm to provide direct measurement of orientation and angular velocity.
- Identified fabrication method to co-fabricate clocks and inertial sensors into a ten cubic millimeter package for navigation microsystems through multi-layer packaging of inertial sensors, clocks and environmental isolation.
- Demonstrated three-dimensional microfabrication techniques of non-traditional MEMS materials (e.g. diamond, fused silica, bulk metallic glass) for rate integrating gyroscopes that are compatible with large-scale manufacturing.
- Demonstrated small primary atomic/ion clocks with time losses of only 17 ns after one day of operation.
- Completed independent government evaluation of micro inertial navigation technology in a closed-loop (700 m x 800 m), military/residential neighborhood. Demonstrated boot-mounted inertial sensors with 16 m accumulated error after 4 hours of testing.
- Demonstrated a fabrication technique that allows for the integration of timing and inertial measurement unit into a small package.

FY 2013 Plans:
- Demonstrate a microsystem rate-integrating gyroscope to provide directly measured orientation angle and angular velocity.

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
- Demonstrate a fabrication technique to manufacture microsystem rate-integrating gyroscopes, and trimming techniques to increase the level of performance by a factor of ten. - Demonstrate a microsystem that combines a functional timing and inertial measurement unit in a ten cubic millimeter package. - Demonstrate the co-fabrication of an inertial sensor and a calibration stage to enable integration of error correction technologies on the same stage. - Model internal and external sources of error, scale-factor, and bias drift for inertial devices. - Identify self-calibration techniques to compensate for long-term drift. - Demonstrate small primary atomic/ion clocks with time losses of only 1.6 micro-second after one month of operation. ***FY 2014 Plans:*** - Demonstrate a microsystem rate-integrating gyroscope with performance near or at navigation-grade. - Demonstrate a microsystem that combines a functional timing and inertial measurement unit with performance values for time loss of 1 ns/min and Circular Error Probable CEP < 10 m. - Use models for internal and external sources of error to develop on-chip calibration algorithms. - Develop architecture for chip-scale combinatorial atomic navigator. - Demonstrate combinatorial physics for compact systems with a startup time less than a minute using high-accuracy atomic physics-based inertial devices.			
Title: Thermal Management Technologies (TMT) ***Description:*** The goal of the Thermal Management Technologies (TMT) program was to explore and optimize new nanostructured materials and other recent advances for use in thermal management systems. The overall goal of the program was to insert breakthrough materials and structures at all layers of DoD systems, and enable higher power densities, increased performance, and improved efficiency. Modern, high-performance heat spreaders, which use two-phase cooling, were 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 complementary heat sink blower, and increasing the overall system (heat sink and blower) coefficient of performance was another thrust of this program. Another element of this effort 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. Technology will be inserted through DoD industrial firms into future DoD systems. ***FY 2012 Accomplishments:*** - Inserted Thermal Ground Plane 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.	13.391	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
- Completed multiple insertion demonstrations for enhanced heat exchangers, and initiated transitions to platforms. - Demonstrated 10x improvements over state of the art for re-workable thermal interface materials. - Demonstrated high heat density active cooling modules for efficient operation of cooled electronic devices. - Initiated development of near junction thermal transport techniques including high thermal conductivity diamond and microfluidic cooling.			
Accomplishments/Planned Programs Subtotals	55.380	41.466	30.225

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	88.667	69.542	86.855	-	86.855	129.843	144.470	148.068	155.506	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Low Cost Thermal Imager - Manufacturing (LCTI-M)	21.300	20.509	19.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
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 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, USSOCOM and industry will be the transition partners. ***FY 2012 Accomplishments:*** - Developed and reviewed camera design and overall architecture compatible with cell phone platform. - Co-located DoD's prime microbolometer fabrication capability in a commercial 200 mm MEMS Fab line, in order to leverage low-cost manufacturing infrastructure. - Demonstrated small pixel microbolometer producibility and performance. Preliminary results indicated detector performance goal is achievable. - Initiated wafer level vacuum packaging development by establishing technical approach and material selection criteria. First seal tests showed good metal ring formation with good binding strength. - Demonstrated feasibility of wafer scale optics producibility. - Built prototype wafer scale optics for 320x240, 17 micrometer pixel array. Characterization and testing of prototypes are being performed. ***FY 2013 Plans:*** - Establish interim small form-factor camera integration. - Demonstrate and deliver interim 640x480 LCTI-M camera. - Finalize design of low cost IR optics for LCTI-M. - Conduct 2nd LCTI-M program review and plan technology transition. - Demonstrate an integrated smart phone and first prototype thermal camera. ***FY 2014 Plans:*** - Fabricate low cost wafer scale optics for LCTI-M camera. - Demonstrate small form factor camera integration employing 3-D assembly techniques.			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Deliver final 640x480 LCTI-M cameras with test results and 1280X1024 camera engines.			
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 DoDs needs 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 system (NEMS) and nanophotonic devices 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 2012 Accomplishments:*** - Finalized system and subsystem requirements for the lithography demonstrations at 14 nanometer feature sizes. - Designed an optical system which will exhibit patterning performance to the 14 nm node at 11 wafer-level--per-hour-per-column. - Successfully integrated the 3rd generation electron beam column with a Rotary Stage Demonstrator Platform. - Demonstrated a dynamic pattern generator with electron reflection efficiency in excess of 50%. - Demonstrated complex pattern printing in photo sensitive material using a fully programmable dynamic pattern generator, achieving a resolution of 75 nm with a wafer-plane current of 200 nano amps. - Developed a new process to fabricate the electron-focusing lenslets and CMOS shift registers in concert at one location, which will eliminate several failure mechanisms and greatly increase the reliability of dynamic pattern generator fabrication. - Qualified a chemically-amplified resist for patterning with the 3rd generation electron beam column down to the 32 nm node. ***FY 2013 Plans:*** - Design and build a 4th generation electron-beam column capable of 14 nm node lithography. - Demonstrate system-level lithography for at least 3 relevant patterns obtained from an industry partner achieving resolution, critical dimension uniformity, line edge roughness, and layer-to-layer overlay tolerance compatible with the 14 nm node (metal layer geometry half pitch of ~ 32 nm). Throughput will be 1 wafer-level-per-hour-per-column with a wafer-plane current ranging from 0.7-4.2 microamps.	10.834	15.000	0.000
Title: RESOLVE ***Description:*** The goal of RESOLVE is to extend the capability of the Maskless Nanowriter program by developing an e-beam direct-write lithography tool capable of affordable fabrication of custom ASICS down to nodes required by the DoD in the Trusted Foundry. In addition, this program will provide a manufacturing technology for nanoelectromechanical systems (NEMS) and nanophotonics initiatives within the DoD. It is expected that this tool will provide a cost-effective alternative to extreme ultra-violet	0.000	0.000	15.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
lithography for fabrication of deep-sub-micron complementary metal-oxide semiconductor (CMOS) processes and is projected to also meet the objectives required in the commercial sector for high-volume manufacturing. ***FY 2014 Plans:*** - Ship a pre-alpha reflection e-beam lithography tool (developed under the Maskless Nanowriter program) to the Trusted Foundry for evaluation and process development. - Demonstration at the Trusted Foundry of all patterning specifications for advanced nodes derived by an industry partner. - Develop new compact electron-beam column for integration into 6-column cluster designed for ultimate use in a production-level tool.			
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 on 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 additional elements to the array. Excalibur will provide the technology foundation for defense of next generation airborne platforms, including all aircraft flying at altitudes below 50,000 ft, against proliferated, deployed, and next-generation man-portable air-defense systems (MANPADS) and more capable air-to-air missiles converted for use as ground-to-air missiles. Excalibur will enable these platforms to fly at lower altitude and conduct truly persistent, all-weather ground missions, such as reconnaissance despite low-lying cloud cover. Further capabilities may 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 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 a conceptual design and CONOPS development for a High Energy Laser Counter Measure (HELCM) system will be developed to enable a near-term capability for low-altitude self-defense against MANPADS. This technology will transition via industry.	15.642	18.420	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Completed the design, fabrication and procurement of the components for a coherently or spectrally combinable array of 21 array elements, each fed by a compact 1-kW fiber laser amplifier. - Achieved a record 1.93 kW coherent laser combining using a diffractive optical element with 79% efficiency and near-perfect beam quality. - Demonstrated phase locking of a 7 element array over a 7 km outdoor range in turbulent conditions. - Coherently combined 7 high-power fiber lasers in an optical phased array with a total output power of 2.5 kW and near-perfect beam quality. - Initiated 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. - Conduct field measurements to assess the potential of a conceptual proactive search capability for HELCM systems.			
Title: Endurance ***Description:*** The Endurance program will develop technology for pod-mounted lasers to protect a variety of airborne platforms from emerging and legacy electro-optical IR guided surface-to-air missiles. The focus of the Endurance effort will be to develop and test ancillary subsystems, such as a command subsystem, a threat missile warning subsystem, a mechanical support framework, subsystem interfaces, and the design, integration, and testing of a form/fit/function brass-board laser countermeasure. This program is an early application of technology developed in the Excalibur program and will transition via industry. Applied research for this program is budgeted in PE 0602702E, project TT-06. ***FY 2013 Plans:*** - Initiate the design of an integrated, miniaturized, form/fit/function brass-board laser countermeasure that incorporates subsystem modularity and open-architecture design principles. - Design ancillary subsystems (power delivery, thermal management, processing and control, mechanical support framework). ***FY 2014 Plans:*** - Complete the design of an integrated, miniaturized, form/fit/function brass-board laser countermeasure that incorporates subsystem modularity and open-architecture design principles. - Initiate preparations for look-down, shoot-down live-fire testing of the brass-board laser countermeasure.	0.000	6.500	22.800

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Fabricate, assemble and test ancillary subsystems.			
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, one such program was the Compound Semiconductor Materials On Silicon (COSMOS) program, in which transistors of Indium Phosphide (InP) could 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" (SoC) and allow dramatic size, weight and volume reductions for a wide array of system applications. This program has complementary research efforts funded in PE 0601101E, Project ES-01, and in PE 0602716E, Project ELT-01. The Advanced Technology Development part of this program will leverage the 6.1 and 6.2 programs with focus on the establishment of an accessible, manufacturable technology for device-level heterogeneous integration of a wide array of materials and devices (including, for example, multiple electronics and MEMS technologies) with complex silicon-enabled (e.g. CMOS) architectures on a common silicon substrate platform. This part of the program is expected to culminate in accessible foundry processes of DAHI technology and demonstrations of advanced microsystems with innovative architectures and designs that leverage heterogeneous integration. By the end of the program, this effort seeks to establish a technologically mature, sustainable DAHI foundry service to be made available (with appropriate computer-aided design support) to a wide variety of DoD laboratory, FFRDC, academic and industrial designers. ***FY 2014 Plans:*** - Develop a high-yield, high-reliability accessible manufacturing process flow which will be transitioned to a self-sustaining foundry activity providing heterogeneously integrated circuits with at least three materials/devices. Establish heterogeneous integration design/simulation tool flows necessary to realize the full potential of heterogeneous microsystems integration. - Demonstrate capability for supporting multi-project wafer runs using the heterogeneous foundry service under development. - Accelerate development of circuit design techniques and methodologies that enable revolutionary heterogeneously integrated circuit architectures.	0.000	0.000	17.055
Title: FLASH - Scaling Fiber Arrays at Near Perfect Beam Quality	0.000	0.000	13.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Description: The goal of the FLASH program is to demonstrate a high-efficiency, optical phased array that projects a 100-kW-class beam with near perfect beam quality. To accomplish these ends, it will achieve a 4x reduction in the overall size and weight of high-power laser weapons while increasing robustness to make it suitable for deployment in long-endurance or low-observable aircraft. The completed high-energy laser system will enable long range engagement of air, space, and ground targets. ***FY 2014 Plans:*** - Develop and test a prototype coherently combinable fiber laser with an output power of 1.5 KW capable of being light weighted to the level required for system integration. - Demonstrate coherent combining of 100 laser elements. - Finish a comprehensive system requirement review of the entire laser system including fiber lasers, thermal management, power systems, and beam steering.			
Title: Gratings of Regular Arrays and Trim Exposures (GRATE) ***Description:*** The goal of the Gratings of Regular Arrays and Trim Exposures (GRATE) program is to develop revolutionary circuit design methodologies combined with innovative fabrication techniques to enable cost-effective, low-volume fabrication of application specific integrated circuits (ASICs) for DoD applications. The design methodologies will enable a simplified physical layout implementation of circuits by using extremely regular geometries without sacrificing circuit density or performance. These simplified circuit designs will be implemented using high-resolution grating patterns that can be fabricated at high-throughput using either mask-based or maskless lithography. The methodologies developed in this program are expected to reduce significantly the design costs of high-performance DoD ASICs at the advanced complementary metal-oxide semiconductor (CMOS) technology nodes. ***FY 2012 Accomplishments:*** - Demonstrated grating-based design and fabrication of logic/memory "standard cells" and high-speed RF devices using current photolithography processes. - Fabricated analog devices with > 350 GHz performance. - Created a design targeted at 14 nanometer technology for CMOS using optimized logic and memory cells. ***FY 2013 Plans:*** - Fabricate 1-D digital design at the 14 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.	6.208	1.500	0.000

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Through transition to industry, leverage the knowledge gained from manufactured 14 nm CMOS designs to support design-technology co-optimization at the 10 nm and 7 nm CMOS process nodes.			
Title: Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE)	16.596	7.613	0.000
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. Such focal plane arrays can also be used to fabricate very large number of pixels for persistent surveillance applications. ***FY 2012 Accomplishments:*** - Demonstrated a fully integrated 1280x720, 5 micrometer (µm) pitch longwave infrared (LWIR) camera performance at 80 and 120 K. - Designed and fabricated 1024x1024, 18 µm Read Out Integrated Circuit (ROIC) on 8" diameter wafers. ROIC wafers completed ambient temperature probe screening tests for short and open circuits. - Designed and fabricated 1024x1024, 18 µm broadband detector arrays with response from 0.5 to 5 µm. Detectors hybridized to fanout circuits demonstrated dark current density of 10^3 A/cm^2 at 200 K and 10^6 A/cm^2 at 150 K. - Expanded lambda scale detector application space to include Midwave IR (MWIR) and LWIR wavebands. Achieved excellent operability (99.97 %) from 1280x720, 5 µm pitch MWIR arrays. Also achieved excellent MWIR NETD (35.5 mK, 35 Hz, @ 110 K with f/1.65 optics) from 1280x720, 5 µm pixel arrays. - Initiated 6 µm Mercury Cadmium Telluride(HgCdTE) and InGaAs nCBn FPA designs for persistent surveillance applications. - Transitioned a 12um MWIR handheld target spotting camera into production. ***FY 2013 Plans:*** - Optimize broadband detector array fabrication and assembly processes to maximize FPA operability. Hybridize 1024x1024, 18 µm detector arrays to 1024x1024, 18 µm ROICs. - Finalize camera integration and demonstrate broadband (0.5 to 5 µm) performance with 1024x1024, 18 µm FPA. - Fabricate and demonstrate 2048x2048, 5 µm LWIR and MWIR FPAs for helicopter landing under brownout conditions.			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Conduct initial field tests for multi-band rifle scope.			
Title: COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) ***Description:*** The COmpact Ultra-stable Gyro for Absolute Reference (COUGAR) program goal was 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. The COUGAR gyro has a practical and typical size (~ 4 inch diameter) featuring bias stability and sensitivity (or angle random walk), that is more than 100 times better than state-of-the-art gyroscopes. This program is transitioning via industry. ***FY 2012 Accomplishments:*** - Developed bandgap optical fiber realizing >300m lengths of bandgap fiber with higher order mode suppression and polarizing characteristics. - Demonstrated low noise laser suitable for use in COUGAR gyro. - Integrated low noise lasers with control electronics to suppress noise and lock lasers together. - Demonstrated an optical bandgap fiber gyro in the laboratory with < 10 udeg/rt-hr angle random walk.	10.087	0.000	0.000
Title: High Frequency Integrated Vacuum Electronic (HiFIVE) ***Description:*** The objective of the High Frequency Integrated Vacuum Electronics (HiFIVE) program was to develop and demonstrate new high-performance and low-cost technologies for implementing high-power millimeter-wave sources and components. This program developed 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 were 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. This technology is transitioning via industry. ***FY 2012 Accomplishments:*** - Completed final fabrication and initial testing of a high-power amplifier prototype device incorporating HiFIVE micro-fabrication technologies into a compact module form factor. - Performed laboratory measurements of performance and validate RF power levels, including advanced driver amplifiers. - Initiated integration of compact amplifier technology at G-band in a miniaturized tube form factor. - Demonstrated integrated and compact amplifier technology at G-band and the nearby radiolocation bands. - Completed laboratory measurements of performance of miniaturized tube amplifier at 220GHz.	8.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	88.667	69.542	86.855

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C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency | **DATE:** April 2013

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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	246.476	237.859	239.078	-	239.078	216.950	231.448	263.980	260.951	Continuing	Continuing
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	-	41.815	16.487	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	-	125.106	122.669	137.213	-	137.213	112.794	133.078	233.980	247.451	Continuing	Continuing
CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*	-	33.932	42.840	21.120	-	21.120	0.000	0.000	0.000	0.000	Continuing	Continuing
CCC-06: *COMMAND & CONTROL INFORMATION SYSTEMS*	-	45.623	55.863	80.745	-	80.745	104.156	98.370	30.000	13.500	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012
The FY 2014 OCO Request will be submitted at a later date

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.

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

B. Program Change Summary ($ in Millions)	FY 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	261.606	237.859	244.941	-	244.941
Current President's Budget	246.476	237.859	239.078	-	239.078
Total Adjustments	-15.130	0.000	-5.863	-	-5.863
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-8.000	0.000			
• SBIR/STTR Transfer	-7.130	0.000			
• TotalOtherAdjustments	-	-	-5.863	-	-5.863

Change Summary Explanation

FY 2012: Decrease reflects reductions for the SBIR/STTR transfer and an internal below threshold reprogramming.

FY 2014: Decrease reflects completion of research efforts in the Command and Control Information Systems (CCC-01), and Secure Information and Network Systems (CCC-04) projects, partially offset by expanded efforts in the Information Integration project (CCC-02) and Project CCC-06.

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COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	-	41.815	16.487	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
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 2012 Accomplishments:*** - Demonstrated improved performance of quantum devices with reduced decoherence. - Refined numerical models of quantum devices by including more physical processes in order to better understand their operation. ***FY 2013 Plans:*** - Perform small-scale demonstration of key physical devices.	36.815	16.487	0.000
Title: Resilient Command and Control (RC2)	5.000	0.000	0.000

Exhibit R-2A, **RDT&E Project Justification:** PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
Description: The Resilient Command and Control (RC2) program developed 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 re-planning capabilities enabled mission success in the face of C2 system outages. Specific technologies developed under RC2 included advanced analysis, visualization, and planning tools that provided Commanders and their staffs with a dashboard to enhance situation awareness of the C2 architectures and understand the mission impact of outages. The RC2 tools and technologies enabled 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. A transition plan was developed with the Navy PEO C4I Maritime Tactical Command and Control program. ***FY 2012 Accomplishments:*** - Enhanced situational awareness tools by adding dynamic visualization capabilities. - Conducted experiments with users at PACFLT. - Investigated early transition opportunities with Navy PEO C4I Maritime Tactical Command and Control program.			
Accomplishments/Planned Programs Subtotals	41.815	16.487	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency			DATE: April 2013
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COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	-	125.106	122.669	137.213	-	137.213	112.794	133.078	233.980	247.451	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Communications Under Extreme RF Spectrum Conditions (CommEx)	13.253	13.265	12.500
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; local environment assessment (time, space, frequency, polarization); technologies for addressing known attack strategies and interference properties; and antenna, signal processing, modulation, and network optimization technologies. 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 during all aspects of a mission. 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.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Developed and demonstrated two cycles of government evaluated computer model simulations of spectrum analysis, reasoning about interference mitigation choices, interference mitigation, and reasoning update logic. - Demonstrated algorithms to measure cognitive radio jammers and communication network behaviors that characterize state space and behavior of the jammers. - Demonstrated ability of smart antenna technology to create deep nulls. - Integrated live hardware into 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. - Performed experiments and simulations that model legacy waveforms and interference sources not previously seen by the system. - Developed hardware, firmware, and software using CommEx technologies, and corresponding application programming interfaces and drivers in the radio to understand and control system performance. - Emulated hardware, firmware, and software using prototyping technologies, and developed corresponding application programming interfaces and drivers to understand and control system performance. - Demonstrated distributed Multiple-Input Multiple-Output (MIMO) techniques for spatial beam control, interference mitigation, and communication range extension on testbeds. ***FY 2013 Plans:*** - Perform third cycle of government performance evaluation for computer model simulations of spectrum analysis, reasoning about interference mitigation choices, interference mitigation, and reasoning update logic. - Execute designs of system technologies to address the specific application(s) and platform(s) required for military operations. - Perform laboratory experiments utilizing unknown attack strategies to validate developed mitigation techniques. - Complete system design that addresses technology insertion within size, weight and power constraints. - Utilize properties and limitations of existing jammer technologies to assess performance. - Demonstrate the ability to learn and rapidly recognize behavior patterns of various types of attacks against advanced radios. - Perform laboratory experiments with brassboard and realistic communication systems to validate performance. ***FY 2014 Plans:*** - Validate the size, weight, power, cost, and network overhead of systems that implement the principles developed in this program. - Integrate the developed detailed technology and algorithms into specific hardware and platforms to assure that dynamic range, realistic multipath and clutter, and other implementation specifics can be integrated into communication system. - Develop architecture to allow CommEx technology to be inserted into assessment platforms for military utility.			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Conduct field evaluations and demonstrations to determine military utility.			
Title: Computational Leverage Against Surveillance Systems (CLASS)	19.937	18.200	27.000
Description: 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. The Computational Leverage Against Surveillance Systems (CLASS) program seeks new ways to protect our signals from exploitation by increasingly sophisticated adversaries and to do so in a way that can be maintained as commercial 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. Another track of the program will extend the CLASS technology to provide Low Probability of Intercept (LPI) communications. These techniques will reduce the detectability of communications signals by a factor of 1,000x beyond current capabilities. Scalable performance will allow LPI techniques to better trade information rate for communications capacity. Technologies from this program are planned to transfer to the U.S. Army (for ground system applications) and to USAF (for airborne applications). ***FY 2012 Accomplishments:*** - Initiated development of waveform complexity and interference exploitation technologies. - Initiated the integrated circuit system integration process. - Completed test bed development and evaluated the performance of candidate technologies. ***FY 2013 Plans:*** - Integrate hardware and firmware technology into volume integrated circuits. - Develop test and application driver software for CLASS technology. - Initiate development of modular CLASS products. - Develop Low-probability of Detection/Low-probability of Intercept (LPD/LPI) signaling techniques. ***FY 2014 Plans:*** - Finalize design of CLASS RF and Modem integrated circuits. - Integrate application driver software for CLASS technology. - Produce modular CLASS products.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Develop concepts for integrating CLASS technologies with aircraft antennas and communications equipment.			
Title: Content-Based Mobile Edge Networking (CBMEN)	18.206	21.831	11.363
Description: The CBMEN program's goal 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, situational awareness, and command and control information. Advances in communications technologies are enabling high-capacity communications to the edge. However, the current centralized or regional storage and dissemination of information presents reliability and capacity challenges with 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. The commercial system is enabled by infrastructure (e.g. fiber optic networks) that is not available to the warfighter at the edge. This program will leverage commercial technologies to develop, prototype, and demonstrate the networking technologies and information dissemination techniques needed to enable efficient and robust content distribution using dynamic, mobile, ad hoc military networks. CBMEN will be installed and demonstrated on existing radios. Capabilities from this effort will transition to the DoD.			
FY 2012 Accomplishments: - Developed base and objective metrics for scenarios and simulation development for program evaluation and analysis. - Developed software architectures for distributed data dissemination and technologies for dynamic networks. - Implemented a test and evaluation framework to enable quantitative evaluation of capabilities via emulated or over-the-air networks. - Performed over-the-air testing of basic CBMEN software on military and commercial radio networks.			
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.			
FY 2014 Plans: - Develop objective metrics for advanced scenarios and simulation development for program evaluation and analysis. - Develop representative military small unit scenarios for simulations, over-the-air testing, and demonstration. - Demonstrate CBMEN software for content naming, distribution, management, and security in a dynamic mobile environment. - Begin advanced development of CBMEN enabling technologies with increased scale, dynamics, and content rich applications.			
Title: Mobile Hotspots	20.980	17.100	8.450

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Description: Communications requirements are growing exponentially due to the proliferation of high-data rate sensors (full motion video), Unmanned Aerial Vehicles (UAVs), and the emergence of the Soldier/Marine as both an operator and a sensor within military networks. However, limited spectrum availability results in a large disparity between capacity need and availability. Mobile Hotspots will develop an airborne high capacity data distribution network to interconnect groups of tactical users in a manner that is conceptually similar to the commercial tiered approach interconnecting cell towers and wireless hotspots. Mobile Hotspots will exploit advances in millimeter-wave technology and airborne networking to develop a self-organizing, 1 Gbps mobility backbone formed from highly-directional communications links to interconnect mounted and dismounted warfighters, dispersed tactical operations centers, and intelligence, surveillance, and reconnaissance (ISR) assets. Low size, weight and power designs will be integrated with commercial and military communications equipment and mounted on tactical UAVs and ground vehicles to provide network access to mobile users via infrastructureless hotspots that are compatible with existing radios. The Mobile Hotspots program is targeted to transition to the Army and Marine Corps Expeditionary Forces. ***FY 2012 Accomplishments:*** - Initialized development of gimbaled antennas, efficient high-power millimeter wave amplifiers, and airborne networking technologies. - Began development of detailed system and network architecture designs. ***FY 2013 Plans:*** - Explore steerable antenna concepts, self-organizing network protocols, and efficient power amplifier implementations in a network topology to include UAVs, dismounted soldiers, and mobile platforms. - Explore variable data rates, signal processing and ad-hoc networking as a means to achieve extensions in range under varying environmental and weather conditions. - Evaluate capabilities of critical technologies in ground-based laboratory and field evaluations. - Create a system design for integration into a UAV pod and onto a tactical ground vehicle. ***FY 2014 Plans:*** - Manufacture antenna, amplifier, modem, and networking hardware needed to implement a self-organizing network comprising at least five hotspot nodes interconnected by 1 gigabit per second point-to-point millimeter-wave links to form a mobility backbone. - Integrate the Mobile Hotspots technology into pods for mounting on UAVs and tactical ground vehicles. - Evaluate initial capabilities of the Mobile Hotspot prototype network and millimeter-wave mobility backbone in an initial ground-based field experiment. - Identify and implement system and subsystem improvements in preparation for final field experimentation and flight tests.			
Title: Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS)	25.531	15.565	7.500

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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 ad hoc networks and gateways to the Global Information Grid. This program will also develop robust networking architecture(s) and network technologies/processes that will exploit high-density node configurations. AWNS technology is planned for transition to the Services. ***FY 2012 Accomplishments:*** - Performed WNaN System Evaluation with the Army at Ft. Bliss National Integration Experiment 12.1. - Developed and ported network software to a production-ready version of the WNaN radio. - Integrated and demonstrated MUD and MIMO into the WNaN radio as standalone, single function capabilities to establish the feasibility of integrating these waveforms in the WNaN hardware. - Integrated Wireless Distributed Computing (WDC), Content Based Access (CBA), and associated networking functions to support transformation application functionality. - Demonstrated smart antenna functions of beamforming and null steering. - Developed image and full motion video encoding and decoding capability with robustness appropriate to wireless ad hoc networks. - Developed algorithms and expanded performance capabilities to enable network scaling to >1,000 nodes. - Performed experiments utilizing transformational applications within the WNaN node. - Performed experiments to determine Dynamic Spectrum Access utility to share spectrum with other tactical communication systems. - Developed V4 version of the WNaN radio. ***FY 2013 Plans:*** - Integrate smart antenna capabilities into radio nodes.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate capability to integrate additional transformation applications in an integrated network environment. - Integrate MIMO, WDC, advanced Dynamic Spectrum Awareness, and related technologies into the network capabilities to improve network performance, and increase network scalability without increasing spectrum need. - Commence network integration evaluations and field experiments with Marine Corps, Army, Air Force, and Navy to establish feasibility and utility for transition. ***FY 2014 Plans:*** - Complete demonstration of network scaling to support brigade-level utility and scalability to a large numbers of nodes. - Complete network integration evaluations and field experiments with Marine Corps, Army, Air Force, and Navy to establish feasibility and utility for transition.			
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 megabits per second) 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. ***FY 2013 Plans:*** - Assess the fundamental limits of transmitter gain for a distributed ground-based wireless network. - 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. - Develop networking concepts to allow legacy military Mobile ad-hoc networks to make effective use of Fixed Wireless infrastructure. ***FY 2014 Plans:*** - Build prototype infrastructure module supporting 4 channels divided between a legacy military waveform selected in the 2013 effort, and a CLASS extended range waveform.	0.000	10.100	15.500

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Develop and test networking software in a simulation environment to support mobile ad hoc communications with infrastructure. - Measure network performance improvement, throughput and pervasiveness, comparing Mobile Ad Hoc Network with Gateway, and Fixed Wireless network protocol. - Develop self-organizing communications software to automatically configure distributed communication systems without operator configuration.			
Title: Advanced RF Mapping ***Description:*** One of the key advantages on the battlefield is the ability to actively sense and manipulate the radio frequency (RF) environment, enabling reliable and assured communications, as well as effectively mapping and manipulating the adversary's communications in ways that defy their situational awareness, understanding, or response. Current approaches 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 collection assets and the required level of signal processing inhibits our capability to pervasively sense and manipulate at the precision (time, frequency, and space) required for effective action. To address these and other shortfalls, the Advanced RF Mapping program will develop and demonstrate new concepts for sensing and manipulating the RF environment based on distributed rather than centralized collection. This approach will take advantage of the proliferation of RF devices, such as radios and cell phones, on the battlefield. To leverage these existing devices effectively, the program will develop new algorithms that can map the RF environment with minimal communication load between devices. It will also develop approaches to exploit our precise knowledge of the RF environment and the distributed proximity of RF devices to provide reliable and assured communications for our warfighter as well as to infiltrate or negate our adversaries' communications networks. Building upon technologies investigated within 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 to exploit distributed RF collections and to produce a full environmental map of frequency and space as a function of time. - Assess approaches to exploit RF environment knowledge and distributed RF devices to provide new capabilities to assess adversary networks and defend against hostile use of the RF spectrum. ***FY 2014 Plans:*** - Develop and deploy prototype networks employing over dozens of RF devices of different types for experimentation with the RF mapping technology.	0.000	10.300	19.500

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrate First Generation RF mapping capability with the goal to determine the majority of RF signals in tactically relevant VHF and UHF frequencies, using less than 10 devices per square mile while minimizing communications requirements between devices. - Determine the performance improvement for signal detection and identification of RF mapping system over tactically relevant collection times. - Improve RF collection capabilities to cover impaired tactical networks and limited device availability in tactical environments. - Establish baseline capability for assessing hostile networks and defending against hostile use of the RF spectrum.			
Title: Highly Networked Force ***Description:*** A highly networked and enabled force increases efficiency, effectiveness, and safety by making relevant information available when it is needed and at the appropriate location (person/platform/system). 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 connectivity due to networks that cannot keep up with the high rate of change; and lack of assured connectivity due to the impact of misbehaving networks and devices. Technologies developed under this program will be transitioned to the Services. ***FY 2013 Plans:*** - Investigate techniques to determine the integrity of communications nodes and subnetworks from both physical, network, and application-based information. - 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 new routing, naming, and networking mechanisms optimized for addressing network outages and security needs. ***FY 2014 Plans:*** - Develop a simulation model of enterprise-level heterogeneous networks appropriate for investigating the detection and attribution of misbehaving devices and subnetworks. - Develop a wireless network supporting investigation of the new architectures and mechanisms to mitigate the effects of misbehaving devices and networks. - Use the network and model for initial evaluation of the most promising approaches identified in the FY2013 investigations.	0.000	6.000	11.000
Title: Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART) ***Description:*** The Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART) program, last funded in FY 2010, developed a new technology for producing very thin millimeter-wave array apertures and transceivers. The technology development culminated in the demonstration of a large-sized coherent, active electronically-steerable array (AESA)	0.000	3.000	6.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
with an output power density of 5W per square cm and a total layer thickness of less than 1cm. The SMART technology approach resulted in a breakthrough in performance over conventional millimeter-wave approaches. The 3-D multi-layer assemblies developed will greatly reduce AESA packaging complexity and enable very compact, low-cost, millimeter-wave, and radio frequency circuit "building blocks" to combine to form arbitrarily large arrays. New capabilities, such as the ability to construct reconfigurable and/or multi-band AESAs and other MMW circuits, will be enabled by this architectural approach. The SMART program is transitioning through industrial producers of MMW radar and communication system components for DoD applications. Additional funding in FY 2013 and FY 2014 is budgeted to facilitate this transitional work to move beyond laboratory demonstrations to a manufacturing environment consistent with high yield, volume capability, and advanced readiness levels while maintaining performance. An additional goal is to demonstrate the ability to adapt to system-level requirements as obtained from applications such as air-to-air and satellite communications at MMW frequencies, such as serial addressable arrays and large aperture assembly. ***FY 2013 Plans:*** - Build a W-band (94 GHz) SMART phased array prototype with transmit / receive capability. Successfully demonstrate the prototype in the laboratory as a range test set. ***FY 2014 Plans:*** - Initiate transition to wafer-scale array fabrication techniques to realize Technology Readiness Level 6 through process analysis and implementation of recommended improvements. - Increase manufacturability of mm-wave communication arrays through increased throughput of batch-fabricated electronically steered arrays.			
Title: 100 Gb/s RF Backbone ***Description:*** The increasing proliferation of video, voice, chat, and other important data-streams on the battlefield is driving a need for higher capacity, reliable, assured, and all-weather communications that are deployable on a wide range of air, ground, and maritime platforms. The goal of this program is to demonstrate a 100 Gigabit-per-second (Gb/s) radio frequency (RF) backbone that will meet the anticipated mid-term (within 3-10 years) wireless networking requirements of deployed military forces. DARPA's hybrid Free Space Optical Experimental Network Experiment (FOENEX) system has broken the 10 Gb/s wireless network boundary using free-space optical links, but all-weather Ku band components are currently limited to much less than 1Gb/s capacity. Furthermore, the hybrid optical/RF system exhibits size, weight, and power consumption (SWaP) characteristics that preclude deployment on many SWaP-limited platforms. Moving to a millimeter-wave (mmW) solution will provide high capacity as well as all-weather resiliency, yet presents technical challenges that include the generation of higher-order waveforms (beyond common data link), efficient power transmission, high-speed routing, and low-noise receivers. This program will develop the constituent subsystems (waveform generation, efficient power amplifiers, and receivers) and spatial multiplexing architectures	0.000	0.000	10.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
to construct an all-weather mmW 100 Gbps backbone at half the size, weight and power consumption of the current FOENEX system. The 100 Gbps RF Backbone program is intended for transition to multiple Services. ***FY 2014 Plans:*** - Develop millimeter-wave waveforms with higher modulation constellation (i.e., QAM16) to achieve high spectral efficiencies. - Identify promising approaches to achieving power transmission efficiency improvements at millimeter-wave frequencies. - Identify promising low noise-figure receiver technologies for millimeter-wave frequencies. - Identify candidate architectures, hardware, and algorithms for spatial multiplexing to achieve high spectral efficiencies.			
Title: Spectrum Efficiency and Access ***Description:*** Current Presidential Initiatives, FCC Broadband Task Force, and Congressional legislation are working to transition large swaths of spectrum (up to 500 MHz) from Federal (DoD is the primary contributor) to civilian use for broadband telecommunications. The DoD will need more data/sensor capacity over the next decades and will therefore need new technology to operate with less spectrum. The objective of this program is to investigate improvements in spectral reuse (spectrum sharing of sensor/radar bands). The program will leverage technical trends in cooperative sharing to exploit radar anti-jam and interference mitigation technologies that could enable spectrum sharing by allowing overlay of communications within the same spectral footprint. The approach will include exploring real-time control data links between radars and communications systems, and developing the advanced waveforms and components to enable radars and communication networks to operate in close proximity. The ultimate goal is to turn the DoD spectrum loss into a net gain of up to hundreds of MHz in capacity. Technology from this program will be made available to the DoD. ***FY 2014 Plans:*** - Develop concepts and management policies for enabling radars and communications networks to share spectrum spatially and temporally. - Develop models and simulation capability for research on spectrum sharing between radar and communications systems. - Assess the limits on achievable spectral reuse between radar and communications in order to evaluate sharing concepts and implementations.	0.000	0.000	8.400
Title: Military Networking Protocol (MNP) ***Description:*** The Military Networking Protocol (MNP) program creates architectures, protocols and network controllers to enhance security and operation of networks. MNP technologies enforce user authentication, manage network traffic, and automatically configure networks. By enforcing user authentication, military network protocols provide full attribution of every device and track each device's network packets to provide full attribution down to the individual source of bad/erroneous data or malicious activity. MNP prioritization schemes will be controlled by various echelons to address changing mission requirements.	21.268	7.308	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Conducted an initial system test and verification of the MNP architecture and protocols. - Continued the refinement and design of the selected MNP architecture, protocols and network controllers. - Increased the scale of the MNP test-bed for the final test and demonstration. - Coordinated with transition partners 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: Optical & RF Combined Link Experiment (ORCLE) ***Description:*** The Optical & RF Combined Link Experiment (ORCLE) program 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 encompassed 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 improved battlespace communications using a hybrid RF and FSO link in air-to-air-to-ground environments. The central challenge was to enable optical communications bandwidth without giving up RF reliability, regardless of the weather. ORCLE developed 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 was 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 transitioning to the Air Force and Navy. ***FY 2012 Accomplishments:*** - Executed 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. - Validated the ability to provide the warfighter with low latency information for command and control as well as Intelligence, Surveillance, and Reconnaissance (ISR) requirements. - Demonstrated network instantiation and user interfaces to allow high data rate command and control at multiple levels. - Successful demonstration of a network's ability to break the 10 Gb/s wireless network boundary using FSO links helped shape the network architecture for the 100 Gb/s RF Backbone program also budgeted in Project CCC-02.	5.931	0.000	0.000
Accomplishments/Planned Programs Subtotals	125.106	122.669	137.213

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	DATE: April 2013

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-04: *SECURE INFORMATION AND NETWORK SYSTEMS*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*	-	33.932	42.840	21.120	-	21.120	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

Computer and networking technologies have rapidly matured in the last decade with profound effect on the DoD and the nation. The Secure Information and Network Systems project will develop and demonstrate computer and network systems suitable for use in contested cyber domains. Examples of such domains include military networks, U.S. government enterprise networks, critical infrastructure, and embedded computing systems. The project will develop, integrate, and test technologies for re-using software components, countering advanced persistent threats, and detecting compromise on enterprise networks. Technologies will be developed using results generated in projects such as, but not limited to, DARPA's Information & Communications Program Element (PE 0602303E) for potential transition to the Services and Combatant Commands.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Rapid Software Development using Binary Components (RAPID)	20.177	24.340	14.120
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 capabilities will transition to the Services. ***FY 2012 Accomplishments:*** - Identified a baseline intermediary representative language specification for the RAPID system. - Designed and prototyped the RAPID system architecture to enable functional identification and functional extraction. - Demonstrated an initial set of extracted and recombined components on multiple systems. ***FY 2013 Plans:*** - Demonstrate an automated proof-of-concept system showing identification, extraction, and combination of components. - Complete the initial implementation of the user interface. - Deliver initial resulting applications to USCYBERCOM. ***FY 2014 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
- Use in red team training exercises to increase speed. - Test the system on a representative set of applications supplied by military partners. - Initiate end-to-end system transition to the Navy Cyber Warfare Development Group, SPAWAR Atlantic, USSTRATCOM, USCYBERCOM, and other commands.			
Title: Cyber Insider Threat (CINDER) ***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. 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. The program focuses on identifying ongoing adversary missions rather than a person, program, or particular piece of malware. 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 the defense industrial base. ***FY 2012 Accomplishments:*** - Identified constraints for each class/mission and demonstrated constraint detection methodologies. - Quantified probability of detection and probability of false alarm as a function of adversary class and mission. - Designed and built scalable prototypes. ***FY 2013 Plans:*** - Evaluate adversary missions and observables on targeted systems. - Demonstrate cyber espionage detection capability on U.S. Government data sets. - Evaluate avoidance and obfuscation tactics against mission template detection. ***FY 2014 Plans:*** - Finalize evaluation of adversary missions and observables on targeted systems. - Finalize evaluation of avoidance and obfuscation tactics against mission template detection. - Transition to identified national security partner.	13.755	18.500	7.000
Accomplishments/Planned Programs Subtotals	33.932	42.840	21.120

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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*

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013

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-06: *COMMAND & CONTROL INFORMATION SYSTEMS*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
CCC-06: *COMMAND & CONTROL INFORMATION SYSTEMS*	-	45.623	55.863	80.745	-	80.745	104.156	98.370	30.000	13.500	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Classified DARPA Program ***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2012 Accomplishments:*** Details will be provided under separate cover. ***FY 2013 Plans:*** Details will be provided under separate cover. ***FY 2014 Plans:*** Details will be provided under separate cover.	45.623	55.863	80.745
Accomplishments/Planned Programs Subtotals	45.623	55.863	80.745

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	104.662	3.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
CLP-01: *CLASSIFIED DARPA PROGRAMS*	-	104.662	3.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	107.226	3.000	0.000	-	0.000
Current President's Budget	104.662	3.000	0.000	-	0.000
Total Adjustments	-2.564	0.000	0.000	-	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.358	0.000			
• SBIR/STTR Transfer	-2.922	0.000			

Change Summary Explanation

FY 2012: Decrease reflects the SBIR/STTR transfer offset by internal below threshold reprogrammings.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Classified DARPA Programs ***Description:*** Classified DARPA Programs ***FY 2012 Accomplishments:*** Details will be provided under separate cover. ***FY 2013 Plans:***	104.662	3.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	104.662	3.000	0.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	195.582	236.883	259.006	-	259.006	258.106	277.450	264.096	271.190	Continuing	Continuing
NET-01: *JOINT WARFARE SYSTEMS*	-	61.581	73.960	39.363	-	39.363	47.134	78.568	85.766	113.351	Continuing	Continuing
NET-02: *MARITIME SYSTEMS*	-	44.489	34.454	41.943	-	41.943	48.872	69.882	76.330	137.839	Continuing	Continuing
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	89.512	128.469	177.700	-	177.700	162.100	129.000	102.000	20.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014 Base**	**FY 2014 OCO**	**FY 2014 Total**
Previous President's Budget	208.503	236.883	245.684	-	245.684
Current President's Budget	195.582	236.883	259.006	-	259.006
Total Adjustments	-12.921	0.000	13.322	-	13.322
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-7.239	0.000			
• SBIR/STTR Transfer	-5.682	0.000			
• TotalOtherAdjustments	-	-	13.322	-	13.322

Change Summary Explanation

FY 2012: Decrease reflects reductions for the SBIR/STTR transfer and internal below threshold reprogrammings.

FY 2014: Increase reflects minor program repricing.

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency			**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
NET-01: *JOINT WARFARE SYSTEMS*	-	61.581	73.960	39.363	-	39.363	47.134	78.568	85.766	113.351	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: High Energy Liquid Laser Area Defense System (HELLADS) ***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. While the prototype laser weapon system module is in design and development, the HELLADS 150 kilowatt (kW) laser will be made available for demonstration opportunities and transition to the Army and Navy.	23.589	46.491	24.763

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Continued integration efforts to ready the 150 kW laser module for field testing by repolishing and coating optics to handle increased laser flux. - Readied laser beam pointing and tracking optical system for high power operation. - Initiated laser weapon system module prototype conceptual design and system requirements to integrate laser, beam control, power, thermal management, and battle management systems in a configuration able to be integrated to air, ground, and sea-based tactical platforms. - Designed suitable physical and functional platform interfaces for the modularized prototype laser weapon system. ***FY 2013 Plans:*** - Complete risk reduction tests of tracking systems for dynamic targets, demonstrating aimpoint accuracy to support lethal power delivery to test targets in representative battlefield environments. - Complete laboratory checkout and government acceptance of 150 kW laser module; package laser and ship for integration into the high power laser demonstrator system. - Complete high power optics insertion, safety system check-outs, range communications protocol check, and initial high power static operation of laser weapon demonstrator to verify that the laser and its subsystems can safely demonstrate lethal effects on mortars and rockets. - Initiate live fire tests against rocket and mortar fly-outs to demonstrate lethal laser power at mission-relevant ranges. - Complete system requirements review of broad utility laser weapon module subsystems including integrating structure, platform interfaces, beam control, and battle management subsystems for integration on air, ground, or sea-based tactical vehicles. - Initiate preliminary design phase of laser weapon system module prototype for tri-Service employment. - Complete the fabrication of the 150 kW laser and start field test system integration. - Complete subsystem testing of the ground-based demonstrator laser weapon system. - Develop novel beam control alternative concepts designed to enhance lethal power delivery to target in through severe atmospheric turbulence. ***FY 2014 Plans:*** - Complete field testing of ground-based 150 kW demonstrator laser weapon system against rockets and mortars. - Transport demonstrator laser from Army mission (rocket/mortar) relevant ground test site to mountain peak test site to mimic Air Force missions for precision air-to-ground and airborne self-defense demonstrations. - Prosecute live fire targets from mountain peak test site to demonstrate performance of laser weapon system in airborne missions to include targeting of ground vehicles and self-defense against surface to air missiles. - Complete preliminary design and detailed design of laser weapon module prototype's subsystems for integration on a specific air, ground, or sea-based tactical vehicle.			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
- Commence fabrication of the laser weapons system module prototype tailored for the selected Service environment (air, ground or sea) tactical platform. - Initiate preparations for field testing of prototype against the appropriate target set on the selected Service platform.			
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 2012 Accomplishments:*** - Conducted walkout and acceptance testing of system. - Integrated perception and control techniques into the platform to facilitate the use of autonomy. - Conducted trades and selected 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. - Perform experiments to assess the mobility and perception capabilities of the platform from a technology standpoint. - Begin technical and operational assessments with the U.S. Marine Corps to evaluate the abilities of the LS3 platform within mission objectives as applied to the LS3 mission profile. ***FY 2014 Plans:*** - Support and refine system prototypes as necessary. - Participate in final demonstration activities in coordination with the U.S. Marine Corps.	18.558	13.331	5.000
Title: Robotics Challenge* ***Description:*** *Formerly Robotics Olympics Advancements are being made in land-capable, high degree-of-freedom unmanned platforms to enable mobility over complex terrain. Many current prototypes are inspired by biological systems and while proof-of-principle systems have or	8.000	14.138	9.600

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
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 Challenge 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 Challenge program consists of a series of obstacle course style challenge events that will focus on technology solutions to demonstrate and test robot capabilities for disaster response. Robotics Challenge 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 technologies to expand mobility and extend endurance of unmanned platforms, advanced tactile and manipulation capabilities, and tools for cost effective design, validation, and construction of autonomous technology, and human-robot interaction. The 6.2 portion of this program is budgeted in PE 0602702E project TT-04. Anticipated Service users include the Army, Marines, and Special Forces. ***FY 2012 Accomplishments:*** - Developed online outreach support for the DARPA Robotics Challenge Trials. - Conducted DoD and industry baseline assessment. - Commenced configuration of humanoid robot for top Virtual Disaster Response Challenge teams to test algorithms. ***FY 2013 Plans:*** - Complete development of humanoid robot platform for algorithm testing during DARPA Robotics Challenge Trials. - Develop and validate robot simulation system. ***FY 2014 Plans:*** - Coordinate Service participation in Robotics Challenge and apply simulation system to Service areas of interest. - Conduct DARPA Robotics Challenge Trials.			
Title: Network Targeting ***Description:*** The Network Targeting program developed 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 progressively matured the design and technologies required to achieve system performance goals and moved incrementally toward an operational system. The technology is planned to transition to the Services in FY 2013.	5.634	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Optimized and integrated algorithms with modified software radio platform. - Improved timing and accuracy capability by inserting chip scale atomic clocks into radio node. - Performed field experiments at military locations to measure the accuracy of the algorithms.			
Title: Chemical Analysis Sans Machinery (CASM) ***Description:*** The Chemical Analysis Sans Machinery (CASM) program sought to develop novel materials and fabrication methods to produce high throughput, autonomous, low cost, chemical analysis devices. This program will transition to the Services. ***FY 2012 Accomplishments:*** - Tested chemical analysis devices against representative levels of appropriate chemicals. - Improved manufacturing processes to demonstrate clear path to low cost production. - Improved durability and robustness of device for increased shelf-life.	5.800	0.000	0.000
Accomplishments/Planned Programs Subtotals	61.581	73.960	39.363

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency			**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
NET-02: *MARITIME SYSTEMS*	-	44.489	34.454	41.943	-	41.943	48.872	69.882	76.330	137.839	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Distributed Agile Submarine Hunting (DASH) ***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 2012 Accomplishments:*** - Completed in-water feasibility sonar measurements using surrogate sensing subsystems. - Completed designs for fixed passive and unmanned underwater vehicle (UUV)-based deep-ocean subullite prototypes.	36.739	25.454	28.943

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Conducted integration and testing of single node prototypes (sensor/communications) in realistic ocean environments. - Demonstrated non-traditional active sonar concept on operationally relevant data and developed a transition plan with the Navy. - Completed non-acoustic sensor and system studies to guide development trajectories for UAV-based ASW. - Initiated non-acoustic sensor designs for UAV-based antisubmarine warfare (ASW). - Initiated data collections for non-acoustic ASW effort. ***FY 2013 Plans:*** - Integrate multiple sonar nodes into system prototypes scalable to large deep-ocean areas for wide area search (relevant to carrier strike group operations) and surveillance. - Demonstrate the ability to detect U.S. submarines with both passive and active sonar showing scalability to detect the quietest of diesel-electric threat submarines. - Commence testing of initial multi-node communication network for persistent connectivity from seafloor-to-shore. - Initiate planning for the demonstration of multi-node systems. - Complete non-acoustic signature discovery and assessment. ***FY 2014 Plans:*** - Complete development of deep sea prototype system of distributed sonar nodes, both passive and active. - Complete development of distributed multi-node communication network for connectivity between seafloor, surface, and shore or ship. - Demonstrate rapid deployment test of fixed passive sonar and conduct a multi-node passive monitoring of a target at sea. - Demonstrate an extended (months) remote monitoring (sea to shore) capability of a passive sonar barrier network at sea. - Demonstrate multi-node UUV-based active sonar in a deep sea test showing detection and tracking of a real target. - Demonstrate combined passive deep sea barrier with handoff to UUV-based active sonar system at sea. - Conduct at-sea demonstration with extended life sonar nodes.			
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	0.000	8.000	7.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
design of military platforms with the ability to continually adapt their properties to match the demands of a dynamic environment. Technology from this program will transition to the Navy. ***FY 2013 Plans:*** - Initiate the design and construction of a sub-scale high-speed planing boat structure that incorporates arrays of adaptive structural subassemblies made up of mechanical programs of tiered negative stiffness structural elements. ***FY 2014 Plans:*** - Complete construction of sub-scale high-speed planing boat incorporating negative stiffness elements; perform system testing and evaluation with Navy partners, demonstrating the technology in a realistic environment.			
Title: Hydra ***Description:*** The Hydra program will develop and demonstrate advanced capabilities for the undersea deployment and employment of unique payloads. Hydra integrates existing and emerging technologies and the ability to be positioned in the littoral undersea battlespace to create a disruptive capability. The system consists of a container with communications, command and control, energy storage, and standard interfaces for payload systems. It will leverage concepts developed under the TEMP program, PE 0602702E, Project, TT-03. The containers are deployed by various means, depending on the need for speed and stealth and remain on the bottom until awakened for employment. Hydra will develop critical enabling technologies for energy storage and recharging, communications, command and control, deployment, and autonomous operations. Technologies from this program will transition to the Navy. ***FY 2014 Plans:*** - Conduct studies to refine the operational trade space, define limits of current technology, and develop new technical approaches. - Initiate concept designs for the container and potential payloads. - Explore innovative approaches for key enabling technologies such as energy storage, communications, and deployment. - Demonstrate key enabling technologies. - Investigate deployment options and initiate system conceptual design.	0.000	0.000	6.000
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	5.500	1.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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 2012	FY 2013	FY 2014
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. ***FY 2012 Accomplishments:*** - Performed technology trades to assess key vehicle capabilities. - Developed concept of operations. ***FY 2013 Plans:*** - Explore and evaluate the conceptual design of alternative approaches to the UMUV system.			
Title: Blue Laser for Submarine Laser Communications (SLC) ***Description:*** The Blue Laser for Submarine Laser Communications (SLC) program developed the critical laser technology necessary to support the requirements for Non-Acoustic Anti-Submarine Warfare (NAASW), mine detection, and SLC. This program focused on 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 transitioned to the Navy. ***FY 2012 Accomplishments:*** - Transitioned adaptive data rate controllers and Cesium Atomic Line Filter to the Navy.	2.250	0.000	0.000
Accomplishments/Planned Programs Subtotals	44.489	34.454	41.943

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	89.512	128.469	177.700	-	177.700	162.100	129.000	102.000	20.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Classified DARPA Program ***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2012 Accomplishments:*** Details will be provided under separate cover. ***FY 2013 Plans:*** Details will be provided under separate cover. ***FY 2014 Plans:*** Details will be provided under separate cover.	89.512	128.469	177.700
Accomplishments/Planned Programs Subtotals	89.512	128.469	177.700

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	267.900	299.438	286.364	-	286.364	276.749	287.424	283.867	299.484	Continuing	Continuing
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	-	38.121	60.284	49.538	-	49.538	45.458	50.458	55.404	61.897	Continuing	Continuing
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	-	88.118	101.339	117.233	-	117.233	113.878	127.078	133.583	151.583	Continuing	Continuing
SEN-03: *EXPLOITATION SYSTEMS*	-	78.969	63.119	65.093	-	65.093	70.413	76.888	82.880	86.004	Continuing	Continuing
SEN-06: *SENSOR TECHNOLOGY*	-	62.692	74.696	54.500	-	54.500	47.000	33.000	12.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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B. Program Change Summary ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014 Base**	**FY 2014 OCO**	**FY 2014 Total**
Previous President's Budget	271.802	299.438	273.605	-	273.605
Current President's Budget	267.900	299.438	286.364	-	286.364
Total Adjustments	-3.902	0.000	12.759	-	12.759
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	3.506	0.000			
• SBIR/STTR Transfer	-7.408	0.000			
• TotalOtherAdjustments	-	-	12.759	-	12.759

Change Summary Explanation

FY 2012: Decrease reflects the SBIR/STTR transfer offset by internal below threshold reprogrammings.
FY 2014: Increase reflects expansion of efforts supporting ISR in denied areas.

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency			**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	-	38.121	60.284	49.538	-	49.538	45.458	50.458	55.404	61.897	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Adaptable Navigation Systems (ANS)	13.186	16.921	13.200
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, foliage, or other environmental obstacles. 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 will 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 2012 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Evaluated candidate filter, sensor, and architecture design for plug-and-play system. - Conducted tests to compare plug-and-play navigation system performance with existing state-of-the-art. - Developed system specification for platform-specific form factor of ANS reference stations. - Demonstrated SoOp-based ranging and navigation. - Built and began testing of first generation 6-degree-of-freedom cold atom-based inertial measurement unit (IMU) in laboratory. - Designed second generation cold atom-based IMU to meet platform-specified size, weight, and power goals and began planning for field 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 for sea, air, and land-based platforms in GPS-denied mission scenarios. - Field test and evaluate first generation 6-degree-of-freedom cold atom-based IMU. - Begin build of second generation 6-degree-of-freedom cold atom IMU in laboratory. ***FY 2014 Plans:*** - Demonstrate flexible, real-time operation of ANS systems on sea, air, and land-based platforms using relevant sensor suites. - Transition novel navigation measurement technologies, via new sensors, algorithms, or measurement enhancements, into ANS demonstration systems. - Evaluate options for Size, Weight, Power and Cost (SWaP-C)-constrained reference stations that enable full SoOp-based navigation. - Complete second generation 6-degree-of-freedom cold atom IMU.			
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 supporting 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. Commercial processes, such as those used in the smart phone industry, create reference designs for common system functions and features to accelerate system development time, and make it easier to change requirements and upgrade capability. Adopting commercial processes 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 sensor system. The core can be upgraded independently of any particular sensor;	21.346	24.913	11.338

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
sensors can make use of the advances and decreasing cost that is inherent in commercial technology. Commercial technology can be used in the core and commercial development and manufacturing techniques can also be leveraged to further improve 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. The Smart Munitions effort will use ADAPT's sensing, processing, communications, and location capabilities to provide positive identification and man-in-the-loop control of distributed unattended ground sensor systems. The Smart Munitions effort will develop a reference design used to demonstrate capability and develop tactics for unattended sensors. This program will transition to the Services. ***FY 2012 Accomplishments:*** - Manufactured initial version of commercial smart core. - Developed smart core re-usable software and ground mission software. - Defined objectives for distributed sensor systems (ground and UAV) and quantified performance against traditional, non-distributed systems. - Initiated development of a distributed ground sensor systems to be used to evaluate man-in-the-loop control of sensor systems. - Defined objectives for initial field demonstration. ***FY 2013 Plans:*** - Manufacture second version of commercial smart core. - Develop mobile and airborne development kits using the core hardware and software technology. - Refine smart core re-usable software and ground mission software communications, networking, distributed processing, location, and orientation. - Develop and demonstrate Smart Munitions reference design using a ground sensor packaging of the core technology. - Develop image, video detection, tracking, and display utilities to provide positive target identification in support of the Smart Munitions effort. ***FY 2014 Plans:*** - Field test and demonstrate mobile coordinated device operation. - Configure hardware for heterogeneous distributed sensor mission. - Field test heterogeneous distributed sensor mission.			
Title: Multi-Function Optical Sensor ***Description:*** The proliferation of radio frequency (RF)-based countermeasures such as digital radio frequency memory (DRFM) has presented challenges to the effectiveness of data sensors. 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 program leverages emerging high-sensitivity focal plane array (FPA) and	0.000	18.450	25.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
compact, multiband laser systems technology in the near/mid/long-wave infrared bands to enable the development of 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. - Initiate development of variable-waveform, high power lasers that demonstrate high wall plug efficiency. - Develop preliminary system architectures for airborne multi-function optical sensors. - Simulate sensor measurements of targets at relevant ranges including the effects of turbulence and atmospheric scattering. - Initiate development of new algorithms and signal processing approaches for effective use of multi-function optical sensing measurements for target tracking and identification. - Investigate the Concept of Operations (CONOPS) for the deployment of a multi-function optical sensor. ***FY 2014 Plans:*** - Complete design of first-generation prototype sensor through critical design review. - Incorporate results of CONOPS and algorithm performance on simulated data to refine objective system performance requirements. - Initiate the investigation of communications protocols for the multi-optical sensor to interact with other systems and other platforms. - Continue development of sensor data-processing algorithms to improve target tracking and identification. - Initiate advanced system signal-processing methodologies for real-time performance and integration into the second-generation sensor system.			
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 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	3.589	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
concentrations of metal materials like weapons. Technologies developed under this program have been made available to the Army and U.S. SOCOM for transition. ***FY 2012 Accomplishments:*** - Transitioned the radar-based prototype to Army and U.S. SOCOM.			
Accomplishments/Planned Programs Subtotals	38.121	60.284	49.538

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	DATE: April 2013

APPROPRIATION/BUDGET ACTIVITY	R-1 ITEM NOMENCLATURE	PROJECT
0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 3: *Advanced Technology Development (ATD)*	PE 0603767E: *SENSOR TECHNOLOGY*	SEN-02: *SENSORS AND PROCESSING SYSTEMS*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	-	88.118	101.339	117.233	-	117.233	113.878	127.078	133.583	151.583	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Behavioral Learning for Adaptive Electronic Warfare (BLADE)	20.700	16.000	19.600
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 2012 Accomplishments:*** - Conducted laboratory testing to demonstrate detection and characterization of known and unknown communication signals with sufficient fidelity to meet operational requirements.			

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Demonstrated the successful offline optimization of jamming waveforms using active probing and learning techniques against communication threats. - Conducted battle damage assessment performance validation via laboratory testing. - Successfully completed Phase 1 end-to-end system performance evaluation on simulation testbed. ***FY 2013 Plans:*** - Optimize algorithms for real-time operations and port to breadboard computing platforms. - Perform construction, integration, and testing of real-time hardware implementation. - Develop threat libraries and testing methodology. - Create transition plan in concert with relevant programs of record and Service partners. ***FY 2014 Plans:*** - Perform test and evaluation of real-time prototypes based on transition partner provided threats. - Begin implementation to form/fit hardware platform selected by transition partner.			
Title: Adaptive Radar Countermeasures (ARC)* ***Description:*** *Previously part of Behavioral Learning for Adaptive Electronic Warfare (BLADE) The goal of the Adaptive Radar Countermeasures (ARC) program is to provide effective electronic countermeasure (ECM) techniques against new or unknown threat radars. Current airborne electronic warfare (EW) systems rely on the ability to uniquely identify a threat radar system to apply an appropriate preprogrammed countermeasure (CM) technique which can take many months to develop. Countering radar systems is increasingly challenging as digitally programmed radars exhibit novel behaviors and agile waveform characteristics. ARC will develop new processing techniques and algorithms that adapt in real-time to generate suitable countermeasures. Using techniques such as state modeling, machine learning, and system probing, ARC will learn the behavior of the threat system, then choose and implement an appropriate countermeasure strategy. ARC technologies will transition to the U.S. Air Force and Navy. ***FY 2013 Plans:*** - Develop algorithms to isolate novel radar signals in the presence of other hostile, friendly, and neutral signals, and deduce the threat posed by that signal. - Design system architecture and develop preliminary software application programming interfaces and interface control documents. - Develop techniques for synthesizing a countermeasure that achieves a desired effect on the threat radar. ***FY 2014 Plans:*** - Complete detailed ARC system architecture design and validate software interfaces.	0.000	8.041	16.300

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Conduct offline testing to demonstrate signal analysis and characterization of unanticipated or ambiguous radar signals. - Demonstrate accurate assessment of countermeasure effectiveness from over-the-air observable changes in the threat radar signals. - Develop methodologies for closed-loop ARC system testing against adaptive radar threats.			
Title: Military Imaging and Surveillance Technology (MIST) ***Description:*** The Military Imaging and Surveillance Technology (MIST) program will develop a fundamentally new optical Intelligence Surveillance and Reconnaissance (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 MIST program will transition the optical ISR technology to the Air Force, and SOCOM. ***FY 2012 Accomplishments:*** - Completed designs and demonstration of an advanced, high-power pulsed fiber laser system with a size, weight, and power that is suitable for integration on a small or persistent airborne platform. - Completed a Critical Design Review (CDR) level design for the MIST short-range 3-D imaging system. - Completed 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. - Completed development of two quarter-scale MIST 3-D imaging demonstrator prototypes. - Began integrating the high peak-power pulsed laser technology to increase the operating distance of the MIST 3-D imaging effort. - Began development of the MIST short-range 3-D imaging prototype for surveillance and identification applications. - Began to develop designs to extend the MIST operating range for aerial platforms. - Ported algorithms from a Colfax processor to a mini processor board that is camera independent. - Began development of rifle mount crosswind sensor system.	31.159	35.955	35.811

Exhibit R-2A, **RDT&E Project Justification:** PB 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
- Evaluated rifle mounted crosswind sensor technologies. - Designed and developed a near-hypervelocity round for snipers. ***FY 2013 Plans:*** - Complete development of MIST short-range 3-D imaging prototypes. - Complete Preliminary Design Review of the MIST 3-D long-range imaging system for operation on aerial platforms. - Initiate brassboard development and CDR-level design of long-range MIST 3-D imaging technology. - Demonstrate key technologies to enable operation of MIST 3-D imaging technologies at increased ranges. - Demonstrate a fiber laser system compatible with the MIST-long range platforms. - Complete development of and test near-hypervelocity round for snipers. - Transition the near-hypervelocity round. - Investigate the use of crosswind sensor technology to ground and airborne applications. ***FY 2014 Plans:*** - Transition the short-range 3-D imaging prototypes and technology to the Services. - Complete brassboard demonstrations of the long-range 3-D imaging systems, including testing and demonstration of critical subsystem components. - Commence long range 3-D imaging prototype design and development. - Develop most promising crosswind sensor technologies identified for ground and airborne applications.			
Title: Multifunction RF ***Description:*** The Multifunction RF (MFRF) 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 subsystems and exterior antennas on military aircraft, thus enabling greater mission capability with reduced vehicle system integration burden. Transition is planned to the Services. ***FY 2012 Accomplishments:*** - Initiated hardware design and development of MFRF system for advanced DVE sensor and lethality functions. - Completed initial demonstration of advanced silicon tile for electronically scanned antenna for Multifunction RF sensor. - Defined universal synthetic vision interface and demonstrated synthetic vision system in laboratory tests. ***FY 2013 Plans:***	15.800	26.862	26.772

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Begin 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. - Flight test synthetic vision avionics backbone with Government Furnished Equipment sensor on selected aircraft platform. - Investigate advanced silicon tile designs and array backplanes to improve system Size, Weight, and Power (SWaP). ***FY 2014 Plans:*** - Demonstrate silicon based sub-array integrated with digital receiver/exciter. - Complete laboratory testing of advanced DVE sensor suitable for flight testing. - Demonstrate radar Software Development Kit suitable for redefining system functions of MFRF sensor. - Complete development and laboratory demonstration of MFRF sensor integrated with multifunction software development kit.			
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. ***FY 2014 Plans:*** - Complete development of transmitter and receiver components for sensor demonstration. - Initiate hardware design and development of ViSAR system. - Demonstrate performance of laboratory quality objective transmitter amplifier. - Complete phenomenology models to support system simulations.	0.000	11.981	18.750
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-	8.809	2.500	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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. The remaining effort in this program is the HALOE (High Altitude Lidar Operations Experiment) program which 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 Outside Continental United States (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. 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. ***FY 2012 Accomplishments:*** High Altitude Lidar Operations Experiment (HALOE) - Explored 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) - Develop additional applications for the high performance LIDAR components embedded within the HALOE system to optimize size, weight, and power for alternate platforms.			
Title: Autonomous Real-time Ground Ubiquitous Surveillance (ARGUS) ***Description:*** The Autonomous Real-time Ground Ubiquitous Surveillance (ARGUS) program developed airborne sensor systems that provide a persistent, real-time, high-resolution, wide-area, day-night video surveillance capability. The ARGUS Infrared	11.650	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
System (ARGUS-IR) uses an advanced infrared (IR) composite focal plane array (FPA) 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 enables detection and tracking of dismounts as well as vehicles. ARGUS-IR utilizes 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 FPA 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 2012 Accomplishments:*** - Catastrophic mechanical failure of the A-160 aircraft during operational testing precluded the planned transition of the ARGUS-IS to the Army under the ARMY/ARGUS-IS/A-160 (AAA) Quick Reaction Capability (QRC) initiative. - Worked with the Army to integrate ARGUS-IS onto other manned and unmanned platforms to support other QRC initiatives. - Integrated the IR sensor into the gimbal. - Completed interface control documentation to integrate the IR sensor and airborne processing system onto the YEH-60 Blackhawk helicopter for engineering and developmental training.			
Accomplishments/Planned Programs Subtotals	88.118	101.339	117.233

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
SEN-03: *EXPLOITATION SYSTEMS*	-	78.969	63.119	65.093	-	65.093	70.413	76.888	82.880	86.004	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Insight ***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 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 Combatant Commands, initially USCENTCOM, USSOCOM, and USPACOM.	50.205	45.000	45.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Demonstrated the baseline multi-source exploitation, collection, and resource management system and human-machine interface techniques against user-validated operational use cases, scenarios, and concepts of operation (CONOPs) in both physical and virtual test bed environments. - Established a virtual test bed for baseline testing of system scalability and fidelity, and analysis of alternative CONOPs. - Populated a developmental database with additional operationally diverse, real-world collected data to support rapid prototyping of innovative exploitation, resource management, and analytical tools. - Evaluated multi-INT sensor exploitation and control techniques in the virtual test bed. - Conducted a series of increasingly complex system integration demonstrations to validate architectural design leading to the first end-to-end system demonstration. - Performed a limited field test at the physical test bed to demonstrate unique system functionality, component interoperability, data flow, usability, and operational impact. ***FY 2013 Plans:*** - Conduct system integration demonstrations 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. - Integrate the Insight system with live pre-deployment training exercises in coordination with transition partners. - Demonstrate the ability of the system to adapt to expanding missions and evolving tactical and operational environments. - Transition technologies to fill key capability gaps and technology shortfalls for existing programs of record. - Conduct virtual test bed exercises to demonstrate exploitation, resource management, visualization, and simulation capabilities. - Demonstrate mature capabilities in live and virtual environments for transition partners. - Transition initial technologies and capabilities to Service partners. ***FY 2014 Plans:*** - Adapt demonstrated capabilities to emerging operational environments including integration of relevant information sources and sensor models, both existing and emerging. - Augment the reasoning component of the system in support of the mission profiles of emerging operational environments. - Integrate other maturing information technologies and programs. - Demonstrate the initial end-to-end system in live and virtual operational environments.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Tailor component and system level capabilities to specific transition objectives.			
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. WAND technologies apply advanced signal processing, sensor fusion, and platform control to leverage advances in sensor capabilities. Transition is planned to the Air Force, Army, SOCOM, and National Geospatial - Intelligence Agency (NGA). ***FY 2012 Accomplishments:*** - Conducted live-fly data collection to obtain time-coincident wide-area motion imagery (WAMI) and RF detection data. - Completed fabrication and testing of back-end WAMI processor. - Demonstrated improvement in RF geolocation accuracy and transitioned enhanced RF sensor capability to SOCOM. - Demonstrated forensic coincident exploitation of WAMI and RF detection data collected at CONUS test site (Trident Spectre 2012). ***FY 2013 Plans:*** - Integrate and demonstrate techniques on Insight testbed. - Demonstrate live processing of time-coincident WAMI and RF detection data at CONUS test site. - Demonstrate integrated detection of sites, movements, and communications associated with threat network activity. - Demonstrate ability to create accurate WAMI tracks in real time. ***FY 2014 Plans:*** - Deliver prototype multi-entity geospatial activity correlator to NGA and U.S. Air Force. - Transition prototype Gen-2 WAMI processor to U.S. Air Force.	20.874	10.619	6.000
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 to obtain airborne ISR observations of many critical problem areas, and overhead observations are limited by sensor resolution, collection timeline, and platform geometry. However, millions of videos posted worldwide reflect events and areas of interest for national security, and the number is rapidly increasing. WISR will use ground-level video and still images to produce 3-D and 4-D reconstructions of events and 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	0.000	7.500	14.093

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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-03: *EXPLOITATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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. ***FY 2014 Plans:*** - Create techniques for automatically correlating and integrating diverse media types such as still images, videos, audio, and text. - Develop and prototype coding methodologies to describe video scenes in terms of their macroscopic, non-culturally dependent characteristics. - Develop and prototype culturally dependent query engines that allow intelligence analysts to combine sequenced and non-sequenced combinations of macroscopic characteristics to find scenes of relevance to a particular mission analysis.			
Title: Multi-Sensor Exploitation ***Description:*** The Multi-Sensor Exploitation program provided 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. New processing techniques for hyperspectral imaging sensors enabled long duration tracking of vehicles and dismounts. Scalable stochastic modeling and inference techniques yielded 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. The techniques are intended for use in riverine and maritime environments, where extremist and criminal groups threaten political stability, trade routes, and free commerce, map navigable tributary systems, detect and identify threats, and monitor their activity. Potential transition partners include USAFRICOM, USSOUTHCOM, USSOCOM, and intelligence agencies. ***FY 2012 Accomplishments:*** - Demonstrated flow-based tracker improvements using instrumented data and in-theater data. - Developed techniques to compensate for complex atmospheric phenomena and demonstrated capability to detect/track vehicles using airborne longwave infrared (LWIR) hyperspectral data. - Developed and demonstrated LWIR hyperspectral capability for chemical tag detection and ground-based detection of chemical materials of interest on vehicles.	2.690	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2014 Defense Advanced Research Projects Agency		DATE: April 2013
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-03: *EXPLOITATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
- Coordinated results and planned the development of a deployable ground-based prototype (for checkpoint interdiction) with transition partner. - Transitioned 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 developed and integrated exploitation capabilities that find and track 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 make situation assessment manpower and radar resource intensive. This program addressed these issues by (1) developing algorithms that exploit Doppler signature data to classify detections as dismounts, animals, clutter, or vehicles; and (2) developing group tracking software that automatically tracks groups of dismounts and provides an accurate group size ("raid count") to users. The Doppler discriminator and group tracking software were integrated into a stand-alone exploitation system which provides a significantly improved capability for finding and localizing targets under foliage, as well as providing automatic raid count and human/vehicle/animal/clutter classification. The program is transitioning to USSOUTHCOM and USSOCOM. ***FY 2012 Accomplishments:*** - Refined and tested algorithms for performing Doppler discrimination and assessing group state and activity. - Designed and implemented a dismount exploitation architecture that combines the Doppler discriminator and group state estimator modules and demonstrated performance in the laboratory. - Integrated Doppler discriminator and group state tracker into a stand-alone exploitation cell at the U.S. Army Communications-Electronics RD&E Center Intelligence and Information Warfare Directorate (CERDEC I2WD).	5.200	0.000	0.000
Accomplishments/Planned Programs Subtotals	78.969	63.119	65.093

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency		**DATE:** April 2013
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-06: *SENSOR TECHNOLOGY*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
SEN-06: *SENSOR TECHNOLOGY*	-	62.692	74.696	54.500	-	54.500	47.000	33.000	12.000	0.000	Continuing	Continuing

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014
Title: Classified DARPA Program ***Description:*** This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2012 Accomplishments:*** Details will be provided under separate cover. ***FY 2013 Plans:*** Details will be provided under separate cover. ***FY 2014 Plans:*** Details will be provided under separate cover.	62.692	74.696	54.500
Accomplishments/Planned Programs Subtotals	62.692	74.696	54.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, **RDT&E Budget Item Justification:** PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605502E: *SMALL BUSINESS INNOVATION RESEARCH*

COST ($ in Millions)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	74.759	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
SB-01: *SMALL BUSINESS INNOVATION RESEARCH*	-	74.759	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
Quantity of RDT&E Articles												

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

In accordance with Public Law No: 112-81 (National Defense Authorization Act) and Small Business Technology Transfer Program Reauthorization Act, the DARPA Small Business Innovation 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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	0.000	0.000	0.000	-	0.000
Current President's Budget	74.759	0.000	0.000	-	0.000
Total Adjustments	74.759	0.000	0.000	-	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	74.759	0.000			

Change Summary Explanation

FY 2012: Increase reflects SBIR/STTR transfer.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Small Business Innovation Research ***Description:*** Description: The DARPA Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose	74.759	0.000	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
APPROPRIATION/BUDGET ACTIVITY 0400: *Research, Development, Test & Evaluation, Defense-Wide* BA 6: *RDT&E Management Support*	**R-1 ITEM NOMENCLATURE** PE 0605502E: *SMALL BUSINESS INNOVATION RESEARCH*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
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. ***FY 2012 Accomplishments:*** The DARPA SBIR and STTR programs were executed within OSD guidelines.			
Accomplishments/Planned Programs Subtotals	74.759	0.000	0.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Not applicable.

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	1.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
AR-02: *DARPA AGENCY RELOCATION*	-	1.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
Quantity of RDT&E Articles												

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

A. Mission Description and Budget Item Justification

This Program Element is budgeted in the Management Support Budget Activity because it funded the building relocation support cost requirements for the Defense Advanced Research Projects Agency (DARPA). The move to a new facility was 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 prior leased facility did not meet the UFC standards and the lease extended beyond October 2009. This Program Element funded all expenses associated with planning and movement of the Agency to its new location. Initial costs included design and trade studies, costs associated with implementing force protection standards, floor plan layout and planning activities that led up to the move. Further, it funded 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 May 2012.

B. Program Change Summary ($ in Millions)	FY 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	1.000	0.000	0.000	-	0.000
Current President's Budget	1.000	0.000	0.000	-	0.000
Total Adjustments	0.000	0.000	0.000	-	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			

Change Summary Explanation

Not Applicable

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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 2012**	**FY 2013**	**FY 2014**
Title: DARPA Agency Relocation ***Description:*** DARPA Agency Relocation ***FY 2012 Accomplishments:*** - Completed move and restoration of prior facility in accordance with lease requirements.	1.000	0.000	0.000
Accomplishments/Planned Programs Subtotals	1.000	0.000	0.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013#	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	66.689	69.767	71.659	-	71.659	73.182	74.678	76.527	78.509	Continuing	Continuing
MH-01: *MANAGEMENT HQ - R&D*	-	66.689	69.767	71.659	-	71.659	73.182	74.678	76.527	78.509	Continuing	Continuing
Quantity of RDT&E Articles												

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012	FY 2013	FY 2014 Base	FY 2014 OCO	FY 2014 Total
Previous President's Budget	66.689	69.767	71.640	-	71.640
Current President's Budget	66.689	69.767	71.659	-	71.659
Total Adjustments	0.000	0.000	0.019	-	0.019
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	0.000	0.000			
• SBIR/STTR Transfer	0.000	0.000			
• TotalOtherAdjustments	-	-	0.019	-	0.019

Change Summary Explanation

FY 2014: Increase reflects minor repricing.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2012	FY 2013	FY 2014
Title: Management Headquarters ***Description:*** Management Headquarters	66.689	69.767	71.659

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
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 2012	FY 2013	FY 2014
FY 2012 Accomplishments: - Funded civilian salaries and benefits, including bonus package compensation for Section 1101 hires, and administrative support costs. - Funded travel, rent and other infrastructure support costs. - Funded security costs to continue access controls, uniformed guards, and building security requirements. - Funded CFO Act compliance costs. - Funded DARPA share of DoD Acquisition Workforce Fund. ***FY 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. ***FY 2014 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	66.689	69.767	71.659

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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 2014 Defense Advanced Research Projects Agency	**DATE:** April 2013
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)	All Prior Years	FY 2012	FY 2013 #	FY 2014 Base	FY 2014 OCO ##	FY 2014 Total	FY 2015	FY 2016	FY 2017	FY 2018	Cost To Complete	Total Cost
Total Program Element	-	3.471	1.801	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
CYB-01: *CYBER SECURITY INITIATIVE*	-	3.471	1.801	0.000	-	0.000	0.000	0.000	0.000	0.000	Continuing	Continuing
Quantity of RDT&E Articles												

FY 2013 Program is from the FY 2013 President's Budget, submitted February 2012

The FY 2014 OCO Request will be submitted at a later date

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 2012**	**FY 2013**	**FY 2014 Base**	**FY 2014 OCO**	**FY 2014 Total**
Previous President's Budget	5.000	1.801	0.000	-	0.000
Current President's Budget	3.471	1.801	0.000	-	0.000
Total Adjustments	-1.529	0.000	0.000	-	0.000
• Congressional General Reductions	0.000	0.000			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-1.529	0.000			
• SBIR/STTR Transfer	0.000	0.000			

Change Summary Explanation

FY 2012: Decrease reflects a DD 1415 transfer offset by an internal below threshold reprogramming.

C. Accomplishments/Planned Programs ($ in Millions)	**FY 2012**	**FY 2013**	**FY 2014**
Title: Cyber Security Initiative ***Description:*** The goal of the Cyber Security Initiative was 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 developed a network testbed that allows for research experimentation on diverse hardware and software topologies to produce qualitative and	3.471	1.801	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2014 Defense Advanced Research Projects Agency	DATE: April 2013
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 2012	FY 2013	FY 2014
quantitative assessments of cyber security research and development programs through a safe, instrumented experimentation environment. The range is designed to 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 is available for leverage or use by all Federal Government organizations. ***FY 2012 Accomplishments:*** - Completed NCR prototype testing and cyber experimentation. - Continued to develop and test relevant technologies to improve the functionality of the NCR. - Initiated transition of the NCR to the Test Resource Management Center (TRMC). ***FY 2013 Plans:*** - Complete transition of the NCR to TRMC.			
Accomplishments/Planned Programs Subtotals	3.471	1.801	0.000

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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