Department of Defense
Fiscal Year (FY) 2015 Budget Estimates

March 2014

Defense Advanced Research Projects Agency

Defense Wide Justification Book Volume 1 of 5

Research, Development, Test & Evaluation, Defense-Wide

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Department of Defense
FY 2015 President's Budget
Exhibit R-1 FY 2015 President's Budget
Total Obligational Authority
(Dollars in Thousands)

24 Feb 2014

Appropriation	FY 2013 (Base & CCO)	FY 2014 Base Enacted	FY 2014 OCO Enacted	FY 2014 Total Enacted	FY 2015 Base
Research, Development, Test & Eval, DW	2,580,687	2,778,656		2,778,656	2,914,770
Total Research, Development, Test & Evaluation	2,580,687	2,778,656		2,778,656	2,914,770

Department of Defense
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24 Feb 2014

Summary Recap of Budget Activities	FY 2013 (Base & OCO)	FY 2014 Base Enacted	FY 2014 OCO Enacted	FY 2014 Total Enacted	FY 2015 Base
Basic Research	310,893	364,533		364,533	361,994
Applied Research	1,049,398	1,173,586		1,173,586	1,136,550
Advanced Technology Development	1,083,348	1,168,878		1,168,878	1,344,864
Management Support	137,048	71,659		71,659	71,362
Total Research, Development, Test & Evaluation	2,580,687	2,778,656		2,778,656	2,914,770
Summary Recap of FYDP Programs					
Intelligence and Communications	1,961				
Research and Development	2,578,726	2,778,656		2,778,656	2,914,770
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R-1C1: FY 2015 President's Budget (Published Version), as of February 24, 2014 at 08:24:35

Defense-Wide
FY 2015 President's Budget
Exhibit R-1 FY 2015 President's Budget
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(Dollars in Thousands)

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(Dollars in Thousands)

24 Feb 2014

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

Line No	Program Element Number	Item	Act	FY 2013 (Base & OCO)	FY 2014 Base Enacted	FY 2014 OCO Enacted	FY 2014 Total Enacted	FY 2015 Base	Sec
2	0601101E	Defense Research Sciences	01	273,750	315,033		315,033	312,146	U
4	0601117E	Basic Operational Medical Research Science	01	37,143	49,500		49,500	49,848	U
	Basic Research			310,893	364,533		364,533	361,994	
9	0602115E	Biomedical Technology	02	98,097	114,790		114,790	112,242	U
13	0602303E	Information & Communications Technology	02	348,530	399,597		399,597	334,407	U
14	0602304E	Cognitive Computing Systems	02	27,538	16,330		16,330		U
15	0602383E	Biological Warfare Defense	02	15,131	24,537		24,537	44,825	U
20	0602702E	Tactical Technology	02	209,578	218,209		218,209	305,484	U
21	0602715E	Materials and Biological Technology	02	158,175	166,654		166,654	160,389	U
22	0602716E	Electronics Technology	02	192,349	233,469		233,469	179,203	U
	Applied Research			1,049,398	1,173,586		1,173,586	1,136,550	
40	0603286E	Advanced Aerospace Systems	03	168,376	144,804		144,804	129,723	U
41	0603287E	Space Programs and Technology	03	136,427	142,546		142,546	179,883	U
59	0603739E	Advanced Electronics Technologies	03	92,291	107,080		107,080	92,246	U
60	0603760E	Command, Control and Communications Systems	03	189,909	239,078		239,078	243,265	U
61	0603765E	Classified DARPA Programs	03	2,760					U
62	0603766E	Network-Centric Warfare Technology	03	221,490	259,006		259,006	386,926	U
63	0603767E	Sensor Technology	03	272,095	276,364		276,364	312,821	U
	Advanced Technology Development			1,083,348	1,168,878		1,168,878	1,344,864	
155	0605502E	Small Business Innovative Research	06	70,839					U
164	0605898E	Management HQ - R&D	06	64,248	71,659		71,659	71,362	U

R-1C2: FY 2015 President's Budget (Published Version), as of February 24, 2014 at 08:24:35

Defense-Wide
FY 2015 President's Budget
Exhibit R-1 FY 2015 President's Budget
Total Obligational Authority
(Dollars in Thousands)

24 Feb 2014

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

Line No	Program Element Number	Item	Act	FY 2013 (Base & OCO)	FY 2014 Base Enacted	FY 2014 OCO Enacted	FY 2014 Total Enacted	FY 2015 Base	Sec
171	0305103E	Cyber Security Initiative	06	1,961					U
		Management Support		137,048	71,659		71,659	71,362	
Total Research, Development, Test & Eval, DW				2,580,687	2,778,656		2,778,656	2,914,770	

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4	0601117E	Basic Operational Medical Research Science	01	37,143	49,500		49,500	49,848	U
Basic Research				310,893	364,533		364,533	361,994	
9	0602115E	Biomedical Technology	02	98,097	114,790		114,790	112,242	U
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22	0602716E	Electronics Technology	02	192,349	233,469		233,469	179,203	U
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Total Defense Advanced Research Projects Agency				2,580,687	2,778,656		2,778,656	2,914,770	

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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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Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency											Date: March 2014	
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*					R-1 Program Element (Number/Name) PE 0601101E / *DEFENSE RESEARCH SCIENCES*							
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
Total Program Element	-	273.750	315.033	312.146	-	312.146	322.923	340.207	340.784	342.847	-	-
BLS-01: *BIO/INFO/MICRO SCIENCES*	-	31.068	24.871	21.148	-	21.148	16.250	14.425	13.285	13.925	-	-
CCS-02: *MATH AND COMPUTER SCIENCES*	-	67.762	91.022	114.290	-	114.290	133.812	130.729	136.551	138.657	-	-
CYS-01: *CYBER SCIENCES*	-	17.095	26.333	28.627	-	28.627	28.000	12.000	12.000	8.000	-	-
ES-01: *ELECTRONIC SCIENCES*	-	43.349	44.354	30.327	-	30.327	35.876	35.376	34.912	33.502	-	-
MS-01: *MATERIALS SCIENCES*	-	80.326	85.819	85.527	-	85.527	75.624	87.777	82.423	85.763	-	-
TRS-01: *TRANSFORMATIVE SCIENCES*	-	34.150	42.634	32.227	-	32.227	33.361	59.900	61.613	63.000	-	-

The FY 2015 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 of exploiting computer capabilities, including: practical, logical, heuristic, and automated 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; mathematical programs and their potential for defense applications; and new learning mechanisms for systematically upgrading and improving these capabilities.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*

The Cyber Sciences project supports long term national security requirements through scientific research and experimentation in cybersecurity. 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 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.

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 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	309.051	315.033	310.494	-	310.494
Current President's Budget	273.750	315.033	312.146	-	312.146
Total Adjustments	-35.301	-	1.652	-	1.652
• Congressional General Reductions	-0.407	-			
• Congressional Directed Reductions	-22.828	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-4.014	-			
• SBIR/STTR Transfer	-8.052	-			
• TotalOtherAdjustments	-	-	1.652	-	1.652

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004, sequestration adjustments, reprogrammings, and the SBIR/STTR transfer.

FY 2015: Increase reflects minor program repricing.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 1	R-1 Program Element (Number/Name) PE 0601101E / *DEFENSE RESEARCH SCIENCES*	Project (Number/Name) BLS-01 / *BIO/INFO/MICRO SCIENCES*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
BLS-01: *BIO/INFO/MICRO SCIENCES*	-	31.068	24.871	21.148	-	21.148	16.250	14.425	13.285	13.925	-	-

The FY 2015 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, improved training and cognitive rehabilitation, 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 2013	FY 2014	FY 2015
Title: Bio Interfaces	12.000	11.832	8.233

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 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. 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 2013 Accomplishments:
- Defined 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.
- Initiated the development of algorithms designed to predict pertinent time processes active in biological systems (e.g., sleep cycles, metabolic cycles, and disease outbreak cycles).
- Refined temporal signature networks and libraries that dictate temporal process regulation for determination of minimal datasets necessary for validated models.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** BLS-01 / *BIO/INFO/MICRO SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Developed and validated 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. ***FY 2015 Plans:*** - Utilize predictions of cell cycle progression to demonstrate an alternative approach to biofuel production by modulating temporal processes in biofuel producing organisms. - Investigate alternative strategies for treating disease by targeting clocking systems that drive temporal processes such as cell cycle progression and metabolic cycles. - Test the ability of predictive algorithms of biological time to enable an economical and easily administered test to assess and predict human circadian phase from blood. - Expand the use of high-performance computing to help the military replace some animal and human experimentation with in-silico models of cell activity, primarily in cellular dynamics.			
Title: Quantitative Models of the Brain ***Description:*** The Quantitative Models of the Brain program will establish a functional mathematical basis on which to build future advances in cognitive neuroscience, computing capability, and signal processing across the DoD. An important focus of this program will be determining how information is stored and recalled in the brain and other DoD-relevant signals and developing predictive, quantitative models of learning, memory, and measurement. Using this understanding, the program will develop powerful new symbolic computational capabilities for the DoD in a mathematical system that will provide the ability to understand complex and evolving signals and tasks while decreasing software and hardware requirements and other measurement resources. 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 further exploit advances in the understanding and modeling of brain activity and organization to improve training of individuals and teams as well as identify new therapies for cognitive rehabilitation (e.g., TBI, PTSD). Critical to success will be the ability to detect cellular and network-level changes produced in the brain during the formation of new, hierarchically organized memories and memory classes, and to correlate those changes with memory function of animals during performance of behavioral tasks.	5.000	10.092	12.915

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** BLS-01 / *BIO/INFO/MICRO SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Identified fundamental bounds on performance and cost associated with linear and nonlinear signal priors. - Demonstrated novel reconstruction algorithms that incorporate both signal and task priors to enable improved reconstruction quality and/or reduced measurement resources. - Demonstrated visible imaging using 10x fewer measurements than reconstructed pixels. - Demonstrated RADAR imaging using 10x less bandwidth than a conventional non-compressive system. - Exploited the benefit of adaptation in order to achieve additional reductions in performance and/or measurement resources. - Exploited 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. ***FY 2015 Plans:*** - Quantify spatio-temporal patterns of neurochemical activity underlying memory formation. - Extend model and brain regions to account for hierarchical organization of memories (procedural, declarative/episodic). - Demonstrate model prediction of knowledge and skill-based memory encoding. - Develop model of memory encoding using non-invasively recorded neural signals.			
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 2013 Accomplishments:*** - Developed prototype synthetic sensors that utilize biologically inspired quantum effects and model their performance. - Demonstrated, using radio frequency fields, that avian and insect magnetoreception is due to quantum effects through the radical pair mechanism.	4.572	2.947	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrated the biological and evolutionary advantage of quantum effects in photosynthetic systems. ***FY 2014 Plans:*** - Demonstrate prototype quantum biological sensors and measure against equivalent state-of-the-art sensors in order to 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.			
Title: Biological Adaptation, Assembly and Manufacturing ***Description:*** The Biological Adaptation, Assembly and Manufacturing program examined 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 psychological parameters was examined and exploited in order to engineer stability into biological systems required for the military. 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 2013 Accomplishments:*** - Developed sensor suite technologies based on neurobiological mechanisms to measure narrative effect on individuals/groups in real-time. - Studied generalized findings in relation to distinct sub-groups to elucidate potential differences across varying cultures. - Incorporated findings about the neurobiology of culture-dependent and culture-independent variables into models and simulations of narrative influence. - Refined sensor suite technologies.	9.496	-	-
Accomplishments/Planned Programs Subtotals	31.068	24.871	21.148

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 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 1	R-1 Program Element (Number/Name) PE 0601101E / *DEFENSE RESEARCH SCIENCES*	Project (Number/Name) CCS-02 / *MATH AND COMPUTER SCIENCES*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
CCS-02: *MATH AND COMPUTER SCIENCES*	-	67.762	91.022	114.290	-	114.290	133.812	130.729	136.551	138.657	-	-

The FY 2015 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, including: practical, logical, heuristic, and automated 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; mathematical programs and their potential for defense applications; and new learning mechanisms for systematically upgrading and improving these capabilities. Promising techniques will transition to both technology development and system-level projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Unconventional Processing of Signals for Intelligent Data Exploitation (UPSIDE)	10.000	15.000	22.097
Description: The Unconventional Processing of Signals for Intelligent Data Exploitation (UPSIDE) program will address the open problems facing real-time Intelligence, Surveillance and Reconnaissance (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. 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) technology, 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 computing infrastructures 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.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Defined unconventional (non-Boolean) computing methodology and inference module abstraction. - Identified target recognition and tracking application. ***FY 2014 Plans:*** - 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. - Begin fabrication of the emerging device(s). - Begin development of CMOS support chip for emerging devices. ***FY 2015 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.			
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 2013 Accomplishments:*** - Exercised 51 second year options for FY2012 participants to continue research focused on new concepts for microsystem technologies, innovative information technologies, and defense sciences.	14.653	16.000	18.569

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Awarded 25 FY2013 grants for new two-year research efforts across the science and engineering topic areas. - Established and improved approaches to bring appropriate technologies developed through YFA to bear on relevant DoD problems and provided awardees mentorship by program managers and engagement with DARPA to encourage future work that focuses on DoD needs. - Developed important technical achievements that led to immediate commercialization efforts: (1) a portable, disposable and easy-to-operate microfluidic platform for point-of-care assessment of platelet dysfunction; and (2) a label-free high-throughput microfluidic device for the characterization of immune cell states. ***FY 2014 Plans:*** - Exercise second year options for successful 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. - Identify top FY2013 participants as candidates for selection as a Director's Fellow. During this additional year of funding researchers will refine their technology further and align to DoD needs. - Establish approaches to bring appropriate technologies developed through YFA to bear on relevant DoD problems. - Provide awardees mentorship by program managers and engagement with DARPA to encourage future work that focuses on DoD needs. ***FY 2015 Plans:*** - Award Director's Fellowships from top FY2013 participants. During this additional year of funding researchers will refine their technology further and align to DoD needs. - Exercise second year options for FY2014 participants to continue research focused on new concepts for microsystem technologies and defense sciences. - Award FY2015 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. - Provide awardees mentorship by program managers and engagement with DARPA to encourage future work that focuses on DoD needs.			
Title: Graph-theoretical Research in Algorithm Performance & Hardware for Social networks (GRAPHS) ***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	8.251	5.213	4.903

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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 a description of how these quantities vary in both space and time. ***FY 2013 Accomplishments:*** - Derived analytic models for commonly occurring social network configurations such as call graphs. - Characterized normalcy and anomaly in structural signal constituents and formulated a detection methodology that incorporates novel noise models. - Developed Efficient Polynomial Time Approximation Schemes (EPTAS) for relevant graph algorithms. - Tested modeling and detection methods against existing text and citation networks and evaluated their effectiveness. - Developed prototype of a multi-node, customized system leveraging existing hardware that will realize at least a 10 fold performance time improvement in the current state of the art. ***FY 2014 Plans:*** - Develop mathematical models and demonstrate mechanistic methods on use cases in DoD-relevant scenarios including brain science, decision support tools for health and disease prevention and prediction, massive streaming networks, and gene networks. - Investigate and develop probabilistic graph models, statistical measures, and statistical sampling procedures for various graph models. ***FY 2015 Plans:*** - Create a suite of systematic network analysis tools that can be applied to static and dynamic network structures and complex use cases. - Develop near real-time scalable algorithms and models with guaranteed accuracy performance for inference, decision support, and understanding macro-phenomena.			
Title: Probabilistic Programming for Advancing Machine Learning (PPAML)*	-	10.221	15.671
Description: *Previously funded in PE 0602702E, Project TT-13. 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 will increase the number of people who can effectively contribute, will make experts more productive, and will 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			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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. - 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. ***FY 2015 Plans:*** - Identify and develop challenge problems from various military domains with increasing levels of complexity and larger data sets. - Evaluate performance of each probabilistic programming system on each challenge problem. - Extend the front end of a probabilistic programming system with additional functionality, including profilers, debuggers, and model verification/checking tools. - Extend the back end of a probabilistic programming system with additional functionality, such as determining which solver or set of solvers is most appropriate for a given input, improving efficiency of solvers, and compiling inference engines to a range of different hardware targets.			
Title: Big Mechanism ***Description:*** The Big Mechanism program will create new approaches to automated computational intelligence applicable to diverse domains such as biology, cyber, economics, social science, and intelligence. Mastering these domains requires the capability to create abstract yet predictive - ideally causal - models from massive volumes of diverse data generated by human actors, physical sensors, and networked devices. Current modeling approaches are heavily reliant on human insight and expertise, but the complexity of these models is growing exponentially and has now, or will soon, exceed the capacity for human comprehension. Big Mechanism will create technologies to extract and normalize information for incorporation in flexible knowledge bases readily adapted to novel problem scenarios; powerful reasoning engines that can infer general rules from a collection of observations, apply general rules to specific instances, and generate (and compute the likelihood of) the most plausible explanations for a sequence of events; and knowledge synthesis techniques to derive abstract principles and/or create models of extreme complexity consistent with huge volumes of data. Big Mechanism applications will accommodate an operator-in-the-loop by accepting questions posed in human natural language; providing drill-down to reveal the basis for an answer; taking user inputs to improve/correct derived associations, weightings, and conclusions; and querying the operator to clarify ambiguities	-	7.000	15.250

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
and reconcile detected inconsistencies. Big Mechanism techniques will integrate burgeoning data into causal models and explore these models for precise interventions in critical areas such as cancer modeling, systems biology, epidemiology, cyber attribution, open-source intelligence, economic indications and warning, and human-social-cultural-behavioral modeling. This program is an outgrowth of Graph-theoretical Research in Algorithm Performance & Hardware for Social networks (GRAPHS). ***FY 2014 Plans:*** - Formulate new approaches to automated computational intelligence applicable to diverse domains. - Create technologies to extract and normalize diverse information - symbolic, qualitative, and quantitative - for incorporation in flexible knowledge bases readily adapted to novel problem scenarios. - Specialize automated computational intelligence techniques for particular applications in domains such as biology, cyber, and intelligence. ***FY 2015 Plans:*** - Develop reasoning engines that can infer general rules from a collection of observations, apply general rules to specific instances, and generate (and compute the likelihood of) the most plausible explanations for a sequence of events. - Create knowledge synthesis techniques to derive abstract principles and/or create models of extreme complexity consistent with huge volumes of data. - Develop tools for operator drill-down, ambiguity clarification, and inconsistency reconciliation. - Demonstrate automated computational intelligence techniques in one or more application domains.			
Title: Mining and Understanding Software Enclaves (MUSE) ***Description:*** The Mining and Understanding Software Enclaves (MUSE) program will develop program analyses and frameworks for improving the resilience and reliability of complex applications. MUSE techniques will apply machine learning algorithms to large software corpora to repair likely defects and vulnerabilities in existing programs and to discover new programs that conform to desired behaviors and specifications. MUSE frameworks will enable robust execution of large-scale and data-intensive computations. Specific technical challenges include persistent semantic artifact generation and analysis, defect identification and repair, pattern recognition, and specification inference and synthesis. MUSE research will improve the security of intelligence-related applications and enhance computational capabilities in areas such as graph processing, entity extraction, link analysis, high-dimensional data analysis, data/event correlation, and visualization. This program is an outgrowth of Probabilistic Programming for Advancing Machine Learning (PPAML). ***FY 2014 Plans:*** - Formulate approaches for task splitting and assignment to optimize utilization of heterogeneous computing resources. ***FY 2015 Plans:***	-	4.500	9.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop data structures suitable for partitioning across distributed storage and processing infrastructure. - Develop concepts and algorithms for computational resilience and fault-recovery through a combination of fault-tolerance, fault-detection, fault-correction, and checkpointing/rollback.			
Title: Transparent Computing ***Description:*** The Transparent Computing program will develop technologies to enable the implementation of more effective security policies across distributed systems. The scale and complexity of modern information systems obscures linkages between security-related events, the result being that detection of attacks and anomalies must rely on narrow contextual information rather than full knowledge of the event's provenance. This shortcoming facilitates attacks such as masquerade (at the user level) and mimicry (at the machine code level). Conversely, the space of security policies that can be enforced under the current operating paradigm is extremely narrow and restrictive; to the extent that users and administrators are required to make security decisions based on limited information, the default is often to just click through. The Transparent Computing program will pursue several promising approaches to these problems, including active/continuous testing via cooperating defenses, where protection components propagate security-relevant information and enable on-the-fly adaptation of the system security posture and usage controls, and behavior attestation techniques that ensure component interactions are consistent with established behavior profiles without exhaustive enumeration of all acceptable program states. Transparent Computing technologies are particularly important for large integrated systems with diverse components such as distributed surveillance systems, autonomous systems, and enterprise information systems. ***FY 2015 Plans:*** - Formulate approaches for tracking information flows and recovering event provenance to enable more effective detection of attacks and anomalies such as masquerade and mimicry. - Develop active/continuous testing and adaptive security policy schemes that adjust security posture and usage controls in response to information provided by distributed protection components. - Introduce dynamic behavioral attestation techniques and propose and analyze scalable algorithms and implementations.	-	-	10.000
Title: Human and Computer Symbiosis (HCS) ***Description:*** The Human and Computer Symbiosis (HCS) program will develop technology for computers to find and use human sources of information. HCS technology will enable computers to identify when they lack necessary information, generate and send texts containing questions to identified collaborators, and integrate and learn from the replies. Because some questions can be answered only by subject matter experts, collaborators will be asked to answer a question if they can and otherwise to forward the question. Tracking these exchanges will enable the computer to learn to send questions directly to the right subject matter experts in the future. As knowledge is acquired, some computers will specialize and become subject matter experts themselves while other computers will become directories of experts that can provide guidance about where to find knowledge. When enough	-	-	10.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
computers have compiled enough knowledge, humans will start to access them by the same mechanism that the computers use: by asking questions. A major technical challenge concerns the formalism in which questions and answers are posed. Human languages will be adequate for some questions, but sometimes mathematics or pictures or other formalisms will be required. ***FY 2015 Plans:*** - Develop algorithms by which computers can determine what they need to know in a given situation. - Develop algorithms to frame knowledge needs as questions posed in natural language. - Develop algorithms to integrate human-supplied natural language answers into a knowledge base. - Develop algorithms to evaluate the quality of answers an individual provides as the basis for quantifying their value as a subject matter expert.			
Title: Full Spectrum Learning ***Description:*** This program was previously funded in PE 0602702E, TT-06. The Full Spectrum Learning (FSL) program will optimize individualized instruction and educational assessment by leveraging advances in information technology, mobile sensors, large-population datasets, neuroscience, and social emotional constructs. The tools developed under this program will provide real-time assessment of attention, comprehension, and engagement. FSL will transform training research by continuously optimizing and assessing content using population-sized datasets. The result will be the development of novel assessment metrics for future generations of computerized educational technologies and the capability to provide highly individualized instruction across large populations of users. ***FY 2015 Plans:*** - Initiate the development of a suite of tools that quantify the learning process and increase training efficacy and efficiency. - Use sensors (i.e., EEG) for recording of physiologic, environmental, and neurocognitive data. - Develop human/machine interfaces that visualize complex data and information and provide user-adapted feedback. - Create analysis tools that provide learning predictions and recommendations as output.	-	-	6.500
Title: Cortical Processor ***Description:*** Capturing complex spatial and temporal structure in high-bandwidth, noisy, ambiguous data streams to meet DoD's needs cannot be achieved even by state-of-the-art signal/image analysis systems. However, there is a processing structure in nature, the mammalian neocortex, that efficiently captures spatial and temporal structure and routinely solves the most difficult recognition problems in real-time and is a general purpose structure for a range of sensor data processing and motor control execution. The Cortical Processor program will leverage simplified models of known cortical operation to develop a new processor architecture that is optimized for running a family of algorithms known as Hierarchical Temporal Memory (HTM), providing new levels of performance and capabilities to a broad range of data recognition problems. HTM models map well to	-	-	2.300

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
simple, massively parallel, signal processor arrays, and a cortical processor leveraging advances in dense memory structures on a complementary metal-oxide semiconductor (CMOS) chip running at a few watts can perform orders of magnitude larger tasks than HTM systems simulated by commercial efforts on large data-center clusters. And with certain specialized circuits, several orders of magnitude improvement in throughput and efficiency will be possible with the cortical processor, enabling a wide range of powerful, ultra-low power, embedded applications. The Cortical Processor program includes basic scientific exploration into a variety of topics central to the development of this fundamentally new computing methodology. The ultimate goal of the Cortical Processor program is to fabricate an accelerator/ coprocessor, in silicon, that contains thousands of reconfigurable, interconnected HTM modules. HTM algorithm and data representation research will be conducted to determine optimal implementation to efficiently utilize the collective operation of the individual modules to achieve the unique features and functionality required by the cortical processor. Each of the cortical processor modules will communicate with a large subset of other nodes requiring development of dense interconnect technology and research into a variety of on-chip network optimizations for the architecture to achieve the connectivity required. Opportunities for significant improvements in power efficiency and speed will be achieved by leveraging recent advances in dense memory structures, such as multi-level floating gates, processors in memory, or 3D integration. Applied research for the program is budgeted in PE 0602303E, Project IT-02. ***FY 2015 Plans:*** - Begin development of HTM algorithm including new data representations and ability to adapt and scale. - Initiate design of memory and controller, accounting for highly interconnected memory access. - Begin research on-chip networking for communication and computation to meet required power and performance.			
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 and likely future 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.	11.680	13.870	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Tested accuracy of non-player-character reactions to trainees' actions and behaviors. - Developed methods to evaluate the effectiveness of SSIM-trained warfighters during interpersonal interactions with local populations. - Enhanced the video-capture and analysis of trainees' interactions during tasks that require cross-cultural interactions. ***FY 2014 Plans:*** - 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. - Field-test prototypes of new training technologies.			
Title: Engage	7.078	11.815	-
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 among 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. Engage technologies are being transitioned to the Department of Defense Educational Activity (DoDEA). ***FY 2013 Accomplishments:*** - Developed computational models that support learning, instruction, adaptivity, and game assessment. - Improved the problem-solving training platform based on the initial research and testing results. - Re-implemented the various application domain software components using the improved platform. - Continued analysis of methodologies using statistics based on data drawn from a large interactive environment. - Analyzed and assessed changes to existing Engage-based software when applied to different student age groups. - Partnered with DoDEA to begin transition of Engage-based software. ***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.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop design and simulation tools that allow students and instructors to determine the operation of a complex electro-mechanical system. - Demonstrate the linking between design and prototyping tools that will allow for in-field manufacturing of failed components. - Demonstrate the linking of instructional design and simulation tools with rapid prototyping machines to allow for the troubleshooting and repair of failed components in electro-mechanical systems.			
Title: Mathematics of Sensing, Exploitation and Evaluation (MSEE)	11.000	4.853	-
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 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 2013 Accomplishments:*** - Refined representation objects to incorporate additional capabilities, such as variable exploitation or execution tasks. - Expanded mathematical framework to allow incorporation of multiple sensing modalities, in particular, video. - Performed initial testing and validation of a prototype automated surveillance system that will be tuned to respond to events of military relevance; formulated and calculated performance metrics that quantify expected performance gains. - Designed and prototyped an algorithmic system architecture that ensures flexibility and extensibility. - Continued creation of modular open system. - Continued implementation of single-modality solution that will demonstrate effectiveness of a 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.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- 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: Computer Science Study Group (CSSG) ***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 2013 Accomplishments:*** - Transitioned successful research outcomes from Classes 2009-2011. - Awarded grants to seven principal investigators who successfully transitioned their research into partnerships with other sources of funding from government or industry. - Co-hosted social media workshop with National Geospatial Intelligence Agency (NGA) and the Department of Homeland Security (DHS). - Facilitated multiple research projects with NSA, NGA, and Army Research Laboratory (ARL). ***FY 2014 Plans:*** - Transition successful research outcomes from Classes 2010-2011.	5.100	2.550	-
Accomplishments/Planned Programs Subtotals	67.762	91.022	114.290

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)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
CYS-01: *CYBER SCIENCES*	-	17.095	26.333	28.627	-	28.627	28.000	12.000	12.000	8.000	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: Automated Program Analysis for Cybersecurity (APAC)	17.095	26.333	20.627

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 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 2013 Accomplishments:
- Measured the effectiveness of 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.
- Conducted competitive engagements to stress the capabilities incorporated in prototype tools.
- Created increasingly effective prototype tools and specific properties from the results of the engagements.

FY 2014 Plans:
- Improve the effectiveness of prototype tools to enable human analysts charged with curating a DoD app store to keep up with a realistic stream of incoming applications.
- Measure the improvement of analyst productivity and effectiveness through further engagements.
- Use measurements against the program metrics to identify prototype tools that are likely candidates for technology transition.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Identify potential transition partners and capture specific user operational needs. ***FY 2015 Plans:*** - Engage in experiments and pilot deployments of prototype tools with transition partners. - Refine tools in response to transition partner challenges. - Select prototype tools for transition and increase their Technology Readiness Level to meet the expectations of transition partners.			
Title: Cyber Computational Intelligence (CCI) ***Description:*** The Cyber Computational Intelligence (CCI) program will create new approaches to computational intelligence specialized to the cyber domain. In enterprise networks and Internet autonomous systems, huge volumes of event data are generated by diverse network elements, hosts, and end-point devices. These event data typically do not adhere to any standard, machine-readable format and some may even be provided as plain text warning/error messages intended for a human operator. CCI will create flexible knowledge base and data-scraping technologies to transparently ingest and normalize unstructured event data. In addition, CCI will develop advanced cyber reasoning engines that can extract and apply general rules for traffic flows and network behaviors to infer (and compute the likelihood of) the most plausible explanations for anomalous network activity. CCI technologies will facilitate the use of event data for monitoring network health, detecting zero-day attacks, optimizing network performance, maintaining network performance during a cyber attack, and reconstituting network capabilities in the aftermath of an attack. ***FY 2015 Plans:*** - Create flexible knowledge base and data-scraping technologies to transparently ingest and normalize unstructured event data generated by diverse network elements, hosts, and end-point devices. - Develop pattern recognition, anomaly detection, and machine learning techniques that generate indications and warning for zero-day attacks. - Formulate network management, control, and reconstitution as an optimization problem amenable to automated reasoning.	-	-	8.000
Accomplishments/Planned Programs Subtotals	17.095	26.333	28.627

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)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
ES-01: *ELECTRONIC SCIENCES*	-	43.349	44.354	30.327	-	30.327	35.876	35.376	34.912	33.502	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: Microscale Plasma Devices (MPD)	3.000	5.000	2.000
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, high carrier-density, micro-plasma switches capable of operating in extreme conditions, such as high-radiation and high-temperature environments. Specific focus will be given to methods that provide efficient generation of ions that can perform robust signal processing of radio frequency (RF) through light electromagnetic energy over a range of gas pressures. Applications for such devices are far reaching, including the construction of complete high-frequency plasma-based circuits, and microsystems 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. MPD-based microsystems are demonstrated in DoD applications where electronic systems must survive in extreme environments. 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 high carrier density regimes.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
MPD will focus on expanding the design space for plasma devices enabling revolutionary advances in micro-plasma 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 in terms of speed of operation and robustness in extreme environments. 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 2013 Accomplishments:*** - Optimized plasma cavity environment for plasma generation at ultra-high (1-20 atm) pressures with emphasis on robust electronic switching. - Improved robustness of microscale plasma devices with carrier density exceeding 10E18 per cubic centimeter. - Continued to investigate effects of high temperature environments on plasma generation and microscale devices at temperatures exceeding 600 degrees Celsius. - Determined optimal parameters including gas pressure and mixture necessary for < 100 picosecond MPD switching speeds needed for robust survivability in high power electromagnetic fields. - Improved robustness of MPD devices operating in extreme radiation environments to improve average lifetime orders of magnitude beyond state of art radiation hardened complementary metal-oxide semiconductor (CMOS). - Demonstrated high power microwave conversion and mixing utilizing plasma as a robust, nonlinear upconversion 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. - Determine feasibility of controlling infrared and light via manipulation, absorption and switching utilizing microscale plasmas. - 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. - Determine fundamental frequency, efficiency and power limitations of generating high-power microwave through terahertz (Thz) frequency signals utilizing plasma as a robust, non-linear up-conversion medium. ***FY 2015 Plans:*** - Complete investigations of the study of scaling properties for plasma devices in terms of size, density, robustness and switching speed. - Complete the optimization of devices that perform from RF through light frequencies.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Transition fundamental research findings into improved commercial 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)	20.000	20.000	20.000
Description: The Semiconductor Technology Advanced Research Network (STARNet) program is a government-industry partnership combining the expertise and resources from select defense, semiconductor, and information companies with those of DARPA to sponsor an external set of academic research teams that are focused on specific technology needs set by experts in industry and government. Efforts under this program will remove the roadblocks to achieving performance needed for future sensing, communication, computing, and memory applications. The program involves close collaboration between these experts and the academic base with industry providing 60% of program funding matched by 40% from DARPA. For both industrial and government participants, leveraging shared research funding for high risk, pre-competitive technology explorations for shared technical hurdles is very attractive. Research in STARNet is divided into a discovery thrust (ACCEL) and an integration thrust (NEXT) executed by virtual academic centers and focused on combining current or emerging technologies to provide new capabilities. ACCEL seeks to discover new material systems, devices, and novel computing/sensing architectures. NEXT involves projects on advanced analog and mixed signal circuitry, complex system design tools, and alternative computing architectures. As the projects in ACCEL mature, it is expected that they will replace the efforts in NEXT that are based on current standard technologies for integrated circuits. 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. ***FY 2013 Accomplishments:*** - Designed "deep-learning" neural networks for machine learning applications such as database search, medical diagnosis, motion tracking, and voice and image recognition based on electron spin-based devices and circuits. Greater than 8 times power reduction relative to complementary metal oxide semiconductor (CMOS) technology is expected. - Fabricated the first prototype of a magnonic holographic memory that has potential for 1 terabyte/cm^2 storage density and data processing greater than 10^18 bits/sec/cm^2 for image processing and recognition. - Demonstrated a simple inverter circuit using extremely low voltage transistors exploiting excitons. - Developed an initial design for a cellular neural network based on tunnel field-effect transistors to significantly reduce the power consumed and increase performance of various information processing functions such as pattern recognition and motion detection. ***FY 2014 Plans:***			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Show proof-of-concept of novel transistor devices with extremely steep turn-on characteristics, allowing the potential for substantial reductions in operating voltage with correspondingly large reductions in power consumption of military electronics. - Work towards achieving the ultimate scalability of silicon-based computing systems with novel data-centric architectures and innovative parallelism strategies. - Satisfy rapidly increasing DoD need for information processing speed and scalability by designing new strategies using non-deterministic computing paradigms and novel nanodevices to compensate for the increasing unreliability of scaled CMOS very-large-scale integration (VLSI). - Develop an integrated, networked swarm of pervasive smart sensors and actuators to monitor and control environments such as buildings, cities and ultimately battlefield spaces. - Monitor and assess progress towards technical goals proposed by Centers, including reductions of 100 times in the power consumption of devices, 100 - 10,000 times lower energy consumption in logic switches, 10 - 100 times higher computational energy efficiency, scalability of technologies to sub-10 nanometer dimensions, development of novel computing architectures, and highly energy-efficient information processing systems inspired in the nervous system. ***FY 2015 Plans:*** - Design VLSI and analog systems based on novel steep-turn-on transistor devices for applications such as lower power imagers, pattern recognition, and scavenging self-powered electronics with 400x better energy-delay product. - Extend the scalability of silicon-based computing systems into the 2020-2030 time frame by exploring the benefits of integrating emerging nano-technologies heterogeneously into silicon-based designs. - Discover, develop, and demonstrate bio- and neuro-inspired information processing architectures that approach the efficiency of brain computation, while aligning well with emerging beyond-CMOS nanoscale fabrics. - Demonstrate components of sensor swarm applications such as building energy efficiency, health care delivery, manufacturing and agriculture, and warfighter situational awareness. - Establish stochastic information processing systems with statistical foundations to achieve 100 times more energy efficiency and robustness in emerging nanoscale functional fabrics for big-data and computationally intensive tasks.			
Title: Arrays at Commercial Timescales (ACT)	-	13.827	6.827
Description: Phased arrays are critical military subsystems 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. New advances in digital circuits at every element in an array panel will allow for ubiquitous phased array technology with heretofore unrealized spectral coverage and capabilities. This program will take a fundamental look at the role of digital arrays and how commonality			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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 are 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:*** - Develop fundamental design techniques suited to common hardware components for phased array elements that can be seamlessly integrated into a wide range of platforms. - Develop fundamental components and sub-systems enabling common array modules, including active interference mitigation technology, analog processing or beamforming techniques, novel channelization techniques, and filter-less transceiver topologies. ***FY 2015 Plans:*** - Continue to develop fundamental technologies and techniques for enabling common array modules. - Investigate transition paths for fundamental technologies into array systems and common modules under development in the applied research portion of this project.			
Title: Micro-coolers for Focal Plane Arrays (MC-FPA) ***Description:*** The Micro-coolers for Focal Plane Arrays (MC-FPA) 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-Thomson (J-T) cooling principle, in a silicon-based Micro Electro-Mechanical Systems (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:*** - Demonstrate 10 mW heat lift and cooling below 200K. - Develop theoretical model for mixed refrigerants and cascaded designs. - Review preliminary designs for MC-FPA cold stage and compressor. - Design and demonstrate a chip-scale, J-T cold-head for a 640 x 480 extended shortwave infrared (e-SWIR, 1-2.4um cutoff) FPA with 4-6 µm unit cell size.	-	1.500	1.500

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Design and test a single-stage micro-cooler with an integrated piezoelectric compressor and cold-head with following metric: 30mm x 20mm x 10mm; 50 g. - Finalize design for a three stage J-T micro-cooler operating down to 195 K. ***FY 2015 Plans:*** - Finalize design for a five-stage J-T micro-cooler operating down to 150 K with 350 mW heat lift.			
Title: Diverse & Accessible Heterogeneous Integration (DAHI) ***Description:*** Prior DARPA efforts have demonstrated the ability to monolithically integrate 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) program takes 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), micro-electromechanical (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 focused on the development of new hetero-integration processes and capabilities that, if successful, will 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 2013 Accomplishments:*** - Continued to develop new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices. - Initiated fabrication and test of heterogeneously integrated ultra-low-noise laser sources and on-chip laser radar systems. - Completed board-level prototypes of ultra-low-noise laser and optoelectronic signal sources and laser radar systems. Basic operating principles were verified, and data is being used for development of optimized systems. - Continued development of noise measurement methodology with sensitivity beyond state-of-the-art for advanced lasers and optoelectronic signal sources being developed within DAHI. ***FY 2014 Plans:***	8.000	4.027	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete development of new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices. - Complete fabrication and test of heterogeneously integrated ultra-low-noise laser sources and on-chip laser radar systems. - Complete development of noise measurement methodology with sensitivity beyond state-of-the-art for advanced lasers and optoelectronic signal sources being developed within DAHI.			
Title: Advanced X-Ray Integrated Sources (AXIS) ***Description:*** The objective of the Advanced X-Ray Integrated Sources (AXIS) program was 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 micro- and nano-electromechanical systems (MEMS and NEMS). Such X-ray sources 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 design verification of integrated circuits to validate trustworthiness as well as Forward Surgical Team imaging of soft tissues and vascular 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 focused 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 medical imaging field based on tunable X-ray wavelengths. ***FY 2013 Accomplishments:*** - Fabricated and demonstrated arrays of closely spaced electron sources with short pulse durations and low emittance for generating small charge bunches. - Fabricated and demonstrated dielectric structures (dielectric loaded waveguides) for accelerating electron bunch to relativistic energies. - Developed ultra-compact short pulse (<1 picosecond), high repetition rate and high power lasers employing saturable gain media. - Demonstrated microfabrication of permanent-magnet-based undulators for X-ray generation. - Demonstrated the utility of coded apertures for generation of phase contrast imaging.	8.094	-	-
Title: Optical Radiation Cooling and Heating in Integrated Devices (ORCHID) ***Description:*** Many Department of Defense (DoD) systems use micro-electromechanical systems (MEMS), including compact accelerometers and gyroscopes for inertial navigation and switches for optical communication and data routing. The performance of such devices is limited, in part, by the architecture and geometry of the sensing configuration and by thermal noise both in	4.255	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
the device and the signal recovery electronics. Advances in co-integration of micro-optical and MEMS technologies enable new hybrid opto-mechanical architectures for improved performance of MEMS devices. The ORCHID program leveraged recent successes within the field of cavity-opto-mechanics to explore the fundamental physics of opto-mechanical interactions on the micro-scale while driving technological development toward smaller and more robust devices capable of field deployment. It is envisioned that such devices will find broad application across DoD, particularly in the areas of microwave generation, force sensing, and optical communications. ***FY 2013 Accomplishments:*** - Demonstrated optical wavelength transfer in an opto-mechanical silica micro-sphere device through the opto-mechanical dark mode, which is immune to thermal noise, with 10% conversion efficiency. - Demonstrated low-noise microwave frequency synthesis using stimulated-Brillouin-scattering in a silica micro-disk. - Demonstrated quantum squeezing of light using an opto-mechanical system. Such light will be useful for surpassing the standard-quantum-limit for displacement sensing. - Demonstrated novel materials and geometries for reduced phase noise in opto-mechanical microwave oscillators.			
Accomplishments/Planned Programs Subtotals	43.349	44.354	30.327

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)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
MS-01: *MATERIALS SCIENCES*	-	80.326	85.819	85.527	-	85.527	75.624	87.777	82.423	85.763	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: Nanoscale/Bio-inspired and MetaMaterials	12.380	16.205	28.417

Description: The research in this thrust area exploits advances in nano/micro-scale and bio-inspired materials, including computationally based materials science, in order to develop unique microstructures, material properties, and functionalities. This area also includes efforts to develop the underlying science for the behavior of materials whose properties have been engineered at the nano/micro-scale level, including metamaterials, digital materials, bio-inspired materials for sensing and actuation, and materials that are designed to mimic biological materials from molecular to macroscopic function. Specific examples of areas of interest include materials that can self-repair, adapt, and respond for soldier protection against chemical and biological threats and materials exhibiting a permanent electric charge (charged matter).

FY 2013 Accomplishments:

- Optimized fabrication methods for materials with architectural features necessary to exhibit predicted properties.
- Initiated experimental optimization of architectural features to demonstrate improvement of selected material properties based on sensitivity analyses and experimental characterization.
- Continued development of materials with architectural features necessary to exhibit predicted properties based on architecture-to-property computational design tools.
- Initiated research to determine extent to which properties normally coupled, can be decoupled using architecture-to-properties design methodology.
- Initiated scalability development to adapt fabrication methods to scaled production while maintaining architectural control.

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.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate targeted enhancement to material properties (e.g., tailored coefficient of thermal expansion (CTE)/energy dissipation and load bearing stiffness). - Establish manufacturability and amenability to scaleup. Provide fabrication and characterization data package. - Initiate development of synthetic methods for preparing large sequence controlled polymer libraries. ***FY 2015 Plans:*** - Investigate the potential for developing compact, high-performance DoD sensors that exploit new insights regarding the physics of biological sensing and communications. - Investigate biomimetic and other emerging micro-robotic approaches to developing miniature, collaborative machines capable of performing precision assembly, disassembly, or removal of materials in highly inaccessible environments. - Identify hierarchical designs for digital materials with novel functional properties such as signal processing, image compression, mathematical operations, or pattern recognition. - Develop a method for screening non-natural polymer libraries for designed properties such as binding to target molecules. - Develop a method for sequencing non-natural polymers at low concentrations.			
Title: Fundamentals of Nanoscale and Emergent Effects and Engineered Devices	5.159	6.500	10.200
Description: The Fundamentals of Nanoscale and Emergent Effects and Engineered Devices program seeks to understand and exploit a broad range of physical properties and new physics that emerge as a result of material and/or device structure and organization at nano-scale dimensions. The insights gained from research performed under this thrust will enable new, more efficient, and powerful material and device architectures that will benefit many DoD applications including controllable photonic devices that operate over multiple wavelengths, ultra-high sensitivity magnetic sensors, high-throughput biochemical sensors for known and unknown (engineered) molecules, advanced armor, ultra-precision air and water purification systems, and advanced armor protection. Examples of physical effects that have been investigated under this thrust include absorption thermodynamics in metal-hydride systems, and correlated electron effects such as superconductivity and magnetism. This thrust has also included investigations of the phenomenology of various biological, physical, and social systems in order to abstract the common features that are responsible for their properties of self-organization, emergent behavior, and physical intelligence. Current efforts are focused on developing 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 2013 Accomplishments:*** - Initiated efforts to identify and characterize metastable, high-pressure phases of gaseous and solid materials (extended solids) that have superior mechanical/functional properties.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated 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. ***FY 2015 Plans:*** - Conduct synthesis of suites of intermediates to lead to selected extended solids. - Characterize the physical, structural, and chemical properties of intermediates synthesized. - Based on computational analysis and experimental results, design retrosynthetic pathways that are synthetically achievable for multistep reaction schemes to fabricate extended solids at reduced pressures.			
Title: Basic Photon Science	20.036	17.889	15.940
Description: The Basic Photon Science thrust is examining the fundamental science of photons, and their interactions in integrated devices, 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, signal processing, 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 for applications such as time distribution from ultrastable optical clocks, ultra-low phase noise microwaves, frequency references, and table-top sources of coherent x-rays, isolated attosecond pulses, and intense neutron sources for medical and non-medical applications. ***FY 2013 Accomplishments:*** - Demonstrated classical optical communications over a free space channel with a rate approaching 100 Terabit/s and separately demonstrated a communication system that achieved a photon information efficiency of 12 bits per received photon. - Demonstrated quantum mechanically secure communications at a secure key information rate greater than 1 Megabits/s and 6 bits per received photon. - Demonstrated high-rate single pixel photon detector with >93% efficiency and less than 1 dark count per second. - Demonstrated a novel polarization-maintaining fiber laser with 220 megahertz (MHz) repetition rate and stabilized carrier envelope offset for robust operation outside of the laboratory.			

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Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** MS-01 / *MATERIALS SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrated and characterized ultrashort-pulse photodetection to realize ultra-low phase noise microwaves at offset frequencies far from carrier, improving the noise floor by ~100 times, and outperforming or matching state-of-the-art low phase noise microwave generation at all offset frequencies. - Constructed a stand-alone, low phase noise microwave oscillator based on optical frequency division from a fiber-based optical frequency comb. - Constructed a 3-4 micron wavelength, 1-10 kilohertz (KHz) laser system with pulse energy of 10 millijoules. ***FY 2014 Plans:*** - Demonstrate quantum mechanically secure communications at a secure key information rate greater than 50 Mb/s and 5 bits per received photon. - Demonstrate a 30 gigahertz (GHz) oscillator using optical frequency division with a micro-frequency comb. - Demonstrate continuous wave operation of a monolithic solid-state laser with milliwatt average output power for integration into a rack mountable ultra-low noise microwave source. - Fabricate silicon nitride microresonators and bulk electro-optically generated frequency comb sources with multiple comb lines for pulse shaping applications including RF photonic filtering. - Design pump and seed lasers for optical parametric chirped pulse amplification for improved x-ray generation efficiency in the water window spectral region. - Demonstrate pump lasers with pulse energies of 2 joules at 800 nanometers and 1 millijoule at 1.8 micron wavelengths for efficient extreme ultraviolet and soft x-ray attosecond pulse generation. ***FY 2015 Plans:*** - Demonstrate 30 (GHz) microwave output from a silica disk microresonator-based optical frequency comb and high power photodiodes for chip-based, ultra-low phase noise microwave generation. - Demonstrate on-chip frequency comb and pulse shaping components utilizing indium phosphide based photonic integrated circuit technology and evaluate with bulk scale reference combs. - Demonstrate high flux soft x-ray production in the biologically critical water window spectral region and use this source for preliminary x-ray imaging demonstrations on the nanometer scale in the water window. - Demonstrate high efficiency-per-shot laser driven neutron production and construct increased repetition rate sample target inserter and laser amplifiers to improve overall neutron flux for radiography applications. - Demonstrate and control ultra-high intensity, long wavelength lasers, which can be used to generate high average power, high energy isolated attosecond (the timescale of electron dynamics in atoms and molecules) optical pulses.			
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	18.591	23.352	30.970

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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 2013 Accomplishments:*** - Demonstrated an optomechanical accelerometer with sensitivity of 10 micro-g/Hz^1/2 (10^-6 of the acceleration due to gravity per root hertz) sensitivity and 35 kHz (kilohertz) bandwidth. - Demonstrated an integrated optomechanical device for coupling optical and microwave photons. Using this device, demonstrated optical readout of microwave circuit and vice versa. - Demonstrated first atomic absorption signal in this clock which is consistent with a performance of 10^-13 fractional frequency stability at 1 second integration, a 100x improvement over current satellite GPS clocks. - Demonstrated soliton mode-locking in on-chip micro-frequency combs resulting in pulse widths of 100 femtoseconds (fs) with a 35 GHz repetition rate. - Developed and demonstrated an ytterbium lattice clock with timing stability of 3.2x 10^-16 at 1 second representing an error < 1 second over 50 billion years. ***FY 2014 Plans:*** - 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. ***FY 2015 Plans:*** - Achieve 3-axis opto-mechanical acceleration sensitivity <200 nano g/sqrt(Hz) over a 10 kHz bandwidth in a packaged device. - Use nitrogen vacancy magnetometer to image the magnetic fields from firing of a single neuron. - Sense functional changes of electronic spin labels in biomolecules (e.g., proteins, lipids) with high spatial and temporal resolution. - Validate optimized performance of slow-beam-optical-clock. - Integrate prototype macroscopic quantum communications system into quantum communications testbed.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Quantify performance of prototype macroscopic quantum communications system under realistic conditions (loss, noise, decoherence) and over secure long haul communications distances using quantum communications testbed.			
Title: Fundamentals of Physical Phenomena	9.991	8.873	-
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; and understanding and quantifying the interaction of electromagnetic and acoustic waves with the plasma in flames. ***FY 2013 Accomplishments:*** - Conducted numerical studies of ion dynamics caused by Ultra Low Frequency (ULF) and of Very Low Frequency (VLF) wave propagation through the ionosphere inside density ducts created by artificial heating. - Experimentally attempted to produce artificial gravity waves. - Experimentally produced field-aligned currents which induced broadband ULF noises < 1 Hz. - Experimentally observed High Frequency (HF)-induced plasma structures and potentially determined relative HF power absorption for different altitudes, frequencies and geophysical conditions. - Continued experiments to quantify the impact of triggered lightning on properties of natural lightning (including the emission of gamma rays, x-rays, ultra violet (UV), visible and near-infrared (IR)/short wave IR, RF, VLF/ULF) and on the properties of upward going lightning and ionospheric phenomena (elves, sprites, whistlers, etc.). - Continued experiments to 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. - Initiated experiments to quantify the impact of compact intracloud discharges on lightning propagation as well as their potential contribution to the production of upward going lightning. ***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 primary ionospheric effects associated with terrestrial lightning. - Test active control of ionospheric geomagnetic substorm evolution process.			
Title: MesoDynamical Architectures (Meso)	13.169	13.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015

Description: The Meso program exploits recently discovered physics at small scales to demonstrate transformative communication, sensing, and computing technologies for the DoD. The program is divided into four thrusts: nonlinearity and noise, coherent collective dynamics, 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 high-performance frequency sources, transistors operating at 100 times lower power than current state-of-the-art, a hand-held biotoxin detector, and attojoule optical switches.

FY 2013 Accomplishments:

- Demonstrated low-phase-noise, temperature-and-acceleration-stable micro-electromechanical systems (MEMS)/nano-electromechanical systems (NEMS) oscillators in a compact package of 25 cubic-millimeters at 800 megahertz frequency (Nonlinearity & Noise thrust).
- Demonstrated the first (MEMS)/(NEMS) oscillator to acquire and track GPS. Meso oscillators were plugged into commercial devices and shown to reliably track GPS (Nonlinearity & Noise thrust).
- Fabricated the initial prototype of the first ever gate-tunable, topological insulator surface-state thermoelectric device (Coherent Collective Dynamics thrust).
- Optimized and integrated materials at large scale to achieve a magnetically gated, ultra-low power, ultra-high switching speed topological insulator transistor (Coherent Collective Dynamics thrust).
- Demonstrated prototype electronic biomolecular sensor with reduced operating current and increased detection capacity and resolution, successfully detecting critical levels of an important neurotoxin and discriminating among mass isotopes at the resolution of nuclear magnetic resonance techniques (Information Transduction thrust).
- Built the first generation of a novel miniature transistor exploiting piezoelectricity and piezoresistivity in materials for low-voltage, low-power operation, and successfully demonstrated operability and essential functionality (Information Transduction thrust).
- Fabricated circuits with up to four nodes exploiting strong nonlinearities in nanophotonic cavities (Coherent Feedback Control thrust).
- Completed software toolkit to simulate nanophotonic circuits incorporating coherent feedback to suppress errors and instabilities (Coherent Feedback Control thrust).

FY 2014 Plans:

- Produce high-performance frequency sources able to overcome the traditional limits in vibration stability, size, and power. Focus on meeting all of the Phase 3 metrics simultaneously on 1 device to provide a capability that will maintain performance in those situations of DoD relevance where current technologies fail (Nonlinearity and Noise thrust).
- Demonstrate programmability of ultra-low dissipation topological-insulator-based interconnect and demonstrate full complementary metal-oxide semiconductor (CMOS) integration (Coherent Collective Dynamics thrust).

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate ultra-low power, ultra-high switching speed magnetic topological insulator transistor and optimize energy per operation to attain 1000 times better performance than that achieved in CMOS (Coherent Collective Dynamics thrust). - Optimize biomolecular sensor prototype, reducing power dissipation, lowering operating current, and incorporating capability to detect multiple toxins simultaneously. Complete miniaturization of sensor to enable a system detects multiple biomolecules in a liquid sample as simply as a standard test strip (Information Transduction thrust). - Fabricate and optimize a third generation piezoelectronic transistor scaled to 10 nanometers lateral dimension, with ON/OFF ratio > 1000, 3 times faster logic with 100 times lower power than CMOS at GHz clock speeds, and switching energies as low as 3 attojoules; develop complementary piezoelectronic transistor logic (inverters, ring oscillators, etc.) and design new complex, high fan-out logic circuits (Information Transduction thrust). - Increase the number of components in a robust nanophotonic circuit to several thousand, reduce their time and energy to switch to one nanosecond and 10 attojoules, and increase the level of suppression of errors by an order of magnitude for maximum reliability (Coherence Feedback Control thrust).			
Title: Atomic Scale Materials and Devices ***Description:*** This thrust examined the fundamental physics of materials at the atomic scale in order to develop new devices and capabilities. New materials and prototype devices were developed to demonstrate a new class of optoelectronics that operate with ultra-low energy dissipation (~100 atom-Joules (aJ)/operation). This class of opto-electronics is enabled by the optical Zeno effect, a counter-intuitive phenomenon whereby an increase in device absorptivity can lead to a decrease in loss. ***FY 2013 Accomplishments:*** - Demonstrated coherent, reversible switching with quantum dot spin in a cavity. - Improved switching speed to 11 picoseconds.	1.000	-	-
Accomplishments/Planned Programs Subtotals	80.326	85.819	85.527

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 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 1	R-1 Program Element (Number/Name) PE 0601101E / *DEFENSE RESEARCH SCIENCES*	Project (Number/Name) TRS-01 / *TRANSFORMATIVE SCIENCES*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
TRS-01: *TRANSFORMATIVE SCIENCES*	-	34.150	42.634	32.227	-	32.227	33.361	59.900	61.613	63.000	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: Social Media in Strategic Communication (SMISC)	14.720	20.161	7.066

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 2013 Accomplishments:

- Refined topic modeling techniques to accurately represent tactically significant content.
- Developed specialized algorithms to recognize purposeful or deceptive messaging and misinformation, persuasion campaigns, and influence operations across social media.
- Applied information theoretic concepts to develop novel approaches for detecting hidden influence mechanisms in social media via information transfer and Granger causality.
- Designed a game theoretic model of optimal and fair allocation of social capital among nodes in networks and used the model to develop an influencer estimation algorithm.

FY 2014 Plans:

- Refine algorithms for real-time detection and tracking of memes at scale.
- Improve specialized algorithms to recognize purposeful or deceptive messaging and misinformation, persuasion campaigns, and influence operations across social media.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** TRS-01 / *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Design algorithms to identify the minimum set of sensors for a given social system based on models used to predict the social dynamics stability distribution and impact on link characteristics. - Design scalable, efficient, and accurate social malware detection algorithms. - Demonstrate methods for countering adversary influence operations using techniques of semi-automated narrative creation based on predictive social dynamics models. - Extend algorithms developed for text-centric social media and micro-blogging to new social multi-media platforms. ***FY 2015 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 the Living Foundries program 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 foundational technological infrastructure to transform biology into an engineering practice, speeding the biological design-build-test-learn 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. fluoropolymers, 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,	9.941	10.973	11.464

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015

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 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 is budgeted in PE 0602715E, Project MBT-02.

FY 2013 Accomplishments:

- Researched and developed standardized test platforms and chassis for quantitative modeling studies to predict platform behavior.
- Developed a software tool for facile annotation and design of new biosynthesis pathways and chassis resulting in a 30x compression of design time (from 1 month to 1 day).
- Developed a new method that decreased DNA design quality control costs by >23X.
- Developed a new large-scale DNA assembly method that can accurately assemble up to 20 pieces of DNA in vitro (previous state of the art was 10) and decreased the failure rate by >4X.
- Began initial experiments to design and test new production pathways for novel materials.
- Developed a software tool that identifies all feasible biosynthetic pathways to a desired product.
- Continued development of device and circuit designs and topologies that are orthogonal to and portable across multiple host chassis. This approach produces minimal cross-talk due to the ability to predict design behavior a priori.
- Began designing, constructing, modeling, and evaluating large scale, hierarchical genetic networks to demonstrate ability to forward engineer bioproduction pathways and functions.
- Initiated studies to research and develop real-time feedback and control mechanisms and tools for more complex and robust experimental design. This work may also enable enhanced control of engineered circuits and networks.
- Continued research, development, and testing of new characterization and debugging tools for synthetic regulatory networks.

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.
- Begin initial demonstration of automated, 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.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** TRS-01 / *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Continue to design and assess production pathways for novel materials. - Develop novel algorithms and software that link 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. ***FY 2015 Plans:*** - Examine design tool innovations to enable forward engineering of novel genetic systems. - Investigate design evaluation tools to enable massively parallel testing, validation, and verification of engineered systems. - Continue development of automated and scalable, large-scale DNA assembly and editing tools and processes. - Research new methods for integrated feedback to exploit high volume data generation and inform future designs and processes.			
Title: Open Manufacturing	9.489	8.000	3.197
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 PE 0602715E, Project MBT-01 under Materials Processing and Manufacturing. ***FY 2013 Accomplishments:*** - Established tools that capture the impact of manufacturing practice and non-linear interactions between components and subsystems and that incorporate parametric and declarative attributes. - Established 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. - Developed new testing methodologies and protocols that support rapid qualification of products. - Demonstrated methods for testing and qualification of new manufacturing technologies using impartial manufacturing centers of expertise. - Performed 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.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 1	**R-1 Program Element (Number/Name)** PE 0601101E / *DEFENSE RESEARCH SCIENCES*	**Project (Number/Name)** TRS-01 / *TRANSFORMATIVE SCIENCES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop metrology methods to support probabilistic process modeling in metals additive manufacturing and bonded composite processing. - Develop a fundamental understanding of the interaction between electromagnetic fields and refractory metals and metal matrix composites based on particle size and material. ***FY 2015 Plans:*** - 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. - Demonstrate Micro-Induction Sintering (MIS) method for additive manufacture of metal and/or ceramic materials in complex geometries. - Demonstrate approach to verifying, validating, and quantifying uncertainty in the developed rapid qualification frameworks.			
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. 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 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 deployment environment. Applications include sensors for conventional indoor/outdoor environments (buildings, transportation, materiel), environmental monitoring over large areas, and simplified diagnosis, treatment, and health monitoring in the field. VAPR will build out an initial capability to make transient electronics a deployable technology for the DoD and Nation. The technological capability developed through VAPR will be demonstrated through a final test vehicle of a transient beacon. 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 (actives and passives), power supply strategies, substrates and encapsulants 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:*** - Establish and characterize transience of alternative semiconductors and other electronic materials for device components. - Begin developing multiple transience mechanisms, including demonstrating mechanically, electrically, and optically triggered transience.	-	3.500	2.500

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Begin developing electronic materials that exhibit a useful combination of transience and the necessary physical characteristics required for sufficient electronic performance. - Develop materials and mechanisms for control of transience effects. - Develop device modeling tools that incorporate transience effects. - Initiate the systematic study of novel transient packaging materials. ***FY 2015 Plans:*** - Establish electronic materials that exhibit a useful combination of transience and the necessary physical characteristics required for sufficient electronic performance. - Enhance device modeling tools that incorporate transience effects.			
Title: ACE (Advanced Capabilities in Engineering Biology) ***Description:*** The Advanced Capabilities in Engineering Biology (ACE) Program will leverage newly developed technologies for engineering biology towards enabling radical new approaches to solving National Security challenges. Engineering biology is emerging as a new field focused on developing the tools to harness the powerful synthetic and functional capabilities of biology. These tools will facilitate design and biological production of new chemicals and materials, sensing capabilities, therapeutics, and numerous other applications. This rapidly developing technological capability opens the door to new national security applications that have heretofore been out of reach, and offers substantial potential advantages in terms of cost and novel functionality. The ACE program will position the U.S. to be first in exploiting the powerful functional capabilities and applications that arise through being able to harness biological systems. A major impediment to engineering biology is that engineered organisms are often less fit than their precursors and are likely to be outcompeted by other organisms. Fundamental work in this area will focus on engineering biological robustness to ensure that engineered organisms perform as designed over the long-term. Research in this area may include developing methods to ensure genetic integrity of organisms, as well as engineering communities of microorganisms to perform useful tasks, ranging from the production of chemicals to the development of stable microbiomes to prevent and treat disease. . ***FY 2015 Plans:*** - Investigate methods to engineer organisms that do not suffer from substantially reduced fitness. - Investigate methods to engineer communities of microorganisms with tunable population dynamics. - Explore methods to rationally reengineer complex microbiomes.	-	-	8.000
Accomplishments/Planned Programs Subtotals	34.150	42.634	32.227

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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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 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601117E / *BASIC OPERATIONAL MEDICAL SCIENCE*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	37.143	49.500	49.848	-	49.848	44.700	44.100	50.260	41.094	-	-
MED-01: *BASIC OPERATIONAL MEDICAL SCIENCE*	-	37.143	49.500	49.848	-	49.848	44.700	44.100	50.260	41.094	-	-

The FY 2015 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 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	39.676	49.500	51.500	-	51.500
Current President's Budget	37.143	49.500	49.848	-	49.848
Total Adjustments	-2.533	-	-1.652	-	-1.652
• Congressional General Reductions	-0.052	-			
• Congressional Directed Reductions	-3.281	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	1.824	-			
• SBIR/STTR Transfer	-1.024	-			
• TotalOtherAdjustments	-	-	-1.652	-	-1.652

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004, sequestration adjustments, and the SBIR/STTR transfer offset by reprogrammings.

FY 2015: Decrease reflects minor program repricing.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601117E / *BASIC OPERATIONAL MEDICAL SCIENCE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Human Assisted Neural Devices	10.810	9.000	9.936

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 the brain utilizes sensory inputs to plan and execute behavioral outputs, and discovering the mechanisms and dynamics underlying neural computation and reorganization. These advances will enable restoration of sensorimotor function 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-destructive neuronal imaging and control techniques that are capable of rapid analysis and interpretation of brain tissue alterations at the cellular scale. Additional research under this effort will generate new methodologies to understand the structural and functional relationships between individual neurons through direct, high-resolution, optical imaging of neuron populations of interest as well as the entire brain.

FY 2013 Accomplishments:
- Expanded the suite of tools and methods to enable optogenetic neuromodulation of specific, diverse neural populations in animal models.
- Demonstrated the ability of non-human primates to perform a dexterous sensorimotor task using only auxiliary sensory information provided through a neural interface.
- Developed 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.
- Explore initial models of the brain driven by understanding of the physical connections between individual neurons of highly trained animals conducting a specific task.
- Generate initial, high-resolution, optical connectivity activity data and corresponding very-large neural data sets.
- Identify novel technologies that have potential for measuring the functional dynamics of cortical columns at spatiotemporal resolution consistent with individual neurons.
- Investigate novel technologies that allow for the control of neurons within a cortical column at single neuron spatiotemporal resolution.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601117E / *BASIC OPERATIONAL MEDICAL SCIENCE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop circuitry models and methods of data analysis that allow for the mathematical characterization and prediction of normal and abnormal cellular processes in the brain. ***FY 2015 Plans:*** - Demonstrate the ability to non-destructively image neural communication between distant cerebral neural circuits in real time. - Demonstrate the ability to simultaneously detect the functional dynamics of multiple individual neurons in the brain over extended periods of time. - Validate the predictive potential of new neural circuitry models by stimulating specific neurons within the circuit to alter behavior and/or function.			
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 2013 Accomplishments:*** - Demonstrated 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. - Demonstrated controlled expression in mammalian cells of synthetic circuit that responds to physiological biomarkers associated with health status. - Quantified sensitivity and specificity of developed molecular approaches designed for deployable diagnostics using physiological concentrations of clinically relevant analytes in complex biospecimens. - Quantified performance of biostabilization reagents/materials demonstrating analytical recovery of clinically relevant molecules equivalent to traditional stabilization methods that require cold-chain storage.	21.620	40.500	39.912

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601117E / *BASIC OPERATIONAL MEDICAL SCIENCE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Quantified performance of methods for room temperature analyses and reagent stabilization demonstrating analytical results with similar-to-enhanced performance as compared to current laboratory methods for clinical diagnostics. - Quantified detection limits achieved with signal amplification methods, demonstrating performance superior to current state of the art methods for quantification of low abundance biomarkers in an actionable timeframe. - Developed 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. - Determined materials properties and fluidic control requirements for integration of diagnostic methodologies. - Quantified the level of antibody and immunoadhesin production directed by the administration of synthetic oligonucleotides in comparison to standard vaccine delivery. - Investigated the impact of the Ribonucleic Acid (RNA) 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 biostabilization reagents/materials with biospecimen types and physical formats appropriate for integration into devices for collection and transport of patient samples for diagnostic analysis, and integration into on-person diagnostic devices. - Demonstrate signal amplification methods in conjunction with processing/assay methods. - Optimize developed sample preparation methods and test efficacy using 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. - Develop advanced materials for incorporation in disposable diagnostic devices. - Optimize advanced microfluidic methods for no/low power flow control. - 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.			
FY 2015 Plans: - Demonstrate ability to administer nucleic acid encoding multiple antibodies to protect against existing, unmet, clinical targets; emerging global infectious diseases; and known, engineered biothreats. - Demonstrate onset of protection within hours after delivery and duration of therapeutic response greater than IV administered antibodies. - Demonstrate optimized, high sensitivity assay methods for protein and nucleic acid biomarkers, suitable for incorporation in deployable devices.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 1: *Basic Research*	**R-1 Program Element (Number/Name)** PE 0601117E / *BASIC OPERATIONAL MEDICAL SCIENCE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate advanced materials properties and incorporation of developed materials into disposable assay formats. - Demonstrate advanced methods for reagent stabilization and delivery for assays developed for deployable devices. - Demonstrate sample preparation methods in conjunction with developed assays and quantify performance metrics. - Demonstrate performance of developed assays using advance no/low power microfluidic methods. - Measure performance of developed diagnostic methods and demonstrate capability to measure clinically relevant analyte levels in appropriate biospecimen matrices. - Demonstrate in mammalian cells the function of a synthetic circuit that can control the timing and level of expression of a protein when expressed from an RNA-based expression vector. - Demonstrate in mammalian cells the function of a synthetic circuit that can integrate at least two physiological signals associated with a change in health status and respond to at least two exogenously added small molecules, and respond with a targeted change in cell state. - Demonstrate the ability to generate a synthetic antibody via continuous evolution that can specifically bind to a defined target in mammalian cells.			
Title: Dialysis-Like Therapeutics	4.713	-	-
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 was to develop a portable device capable of controlling relevant components in the blood volume on clinically relevant time scales. Reaching this goal required 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. Additionally, the device may be effective as a medical countermeasure against various chemical and biological (chem-bio) threat agents, such as viruses, bacteria, fungi, and toxins. Initial basic research developed the component technologies that will ultimately make up the integrated device. Included in this effort was 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 2013 Accomplishments:*** - Improved sensing technologies to achieve continuous detection of pathogens, toxins, and other biomolecules in blood and blood components.			

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Refined microfluidic architectures and coatings for continuous blood flow at high rates of 1.8 L/hour without platelet activation or clotting. - Enhanced label-free separation technologies to successfully remove pathogens, toxins, and select bioagents from blood or blood components by more than 90%. - Validated the sepsis predictive modeling using data from small animal testing within the program.			
Accomplishments/Planned Programs Subtotals	37.143	49.500	49.848

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 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602115E / *BIOMEDICAL TECHNOLOGY*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	98.097	114.790	112.242	-	112.242	100.603	113.059	117.160	120.594	-	-
BT-01: *BIOMEDICAL TECHNOLOGY*	-	98.097	114.790	112.242	-	112.242	100.603	113.059	117.160	120.594	-	-

The FY 2015 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. Bio-warfare defense includes the capability to predict and deflect evolution of natural and engineered emerging pathogen threats, and therapeutics that increase survivability within days of receipt of an unknown pathogen. Continued understanding of infection biomarkers will lead to development of detection devices that can be self-administered and provide a faster ability to diagnose and prevent widespread infection in-theater. Other battlefield technologies include 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 large amounts 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 applied research efforts for dialysis-like therapeutics.

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	110.900	114.790	123.742	-	123.742
Current President's Budget	98.097	114.790	112.242	-	112.242
Total Adjustments	-12.803	-	-11.500	-	-11.500
• Congressional General Reductions	-0.140	-			
• Congressional Directed Reductions	-14.288	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	4.343	-			
• SBIR/STTR Transfer	-2.718	-			
• TotalOtherAdjustments	-	-	-11.500	-	-11.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602115E / *BIOMEDICAL TECHNOLOGY*

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004, sequestration adjustments, and the SBIR/STTR transfer offset by reprogrammings.

FY 2015: Decrease reflects the end of the Revolutionizing Prosthetics program.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Autonomous Diagnostics to Enable Prevention and Therapeutics (ADEPT)	12.175	28.852	23.550

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. Additionally, ADEPT will develop methods to transiently deliver nucleic acids for vaccines and therapeutics, and kinetically control the timing and levels of gene expression so that these drugs will be safe and effective for use in healthy subjects. 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 2013 Accomplishments:

- Demonstrated increased humoral and cellular responses with RNA-based vaccines as compared to benchmark vaccines in vivo.
- Demonstrated increased efficacy of RNA-based vaccines in vivo in small and large animal models.
- Developed device components (sample preparation and detection components) to enable diagnostic device capabilities in low-resourced settings.
- Developed device components (fluidic delivery and multiplex assay module) to enable diagnostic device capabilities designed for the remote clinic.

FY 2014 Plans:

- Demonstrate ability to manipulate the 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 delivery of nucleic acids that transiently produce multiple antibodies.
- Perform quantitative comparison of room temperature assay methods appropriate for integration in devices for low-resourced settings.
- Demonstrate initial component integration and define performance metrics for advanced diagnostic device prototypes suitable for operations in remote clinic and low-resourced settings.

FY 2015 Plans:

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate ability to control the time duration of the therapeutic response suitable for clinical use and rapid public health responses. - Investigate targeted delivery of nucleic acid constructs to specific cell types. - Demonstrate feasibility for controlling pharmacokinetics and immunity modulation components to enable a more potent and broader immune response. - Develop designs for RNA-based vaccines to enable transition to human clinical trials. - Develop designs for initial diagnostic device prototypes, based on highest performing components. - Produce first-generation, integrated diagnostic prototypes designed for remote clinic and low-resourced settings. - Measure quantitative performance of first-generation, integrated diagnostic device prototypes and determine modifications required for performance improvements.			
Title: Tactical Biomedical Technologies	13.188	13.321	12.000
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 hemostasis and wound control for non-compressible hemorrhage in the abdominal space, regardless of wound geometry or location within that space. This thrust will also investigate non-invasive techniques and equipment to use laser energy to treat intracranial hemorrhage through the skull and tissues in a pre-surgical environment. Finally, in order to address logistical delays associated with delivering necessary therapeutics to the battlefield, this thrust will also develop a pharmacy on demand that will provide a rapid response capability to enable far-forward medical providers the ability to manufacture and produce small molecule drugs and biologics. ***FY 2013 Accomplishments:*** - Demonstrated a combined hemostasis agent and delivery mechanism that achieves hemostasis in less than four minutes and does not interfere with standards of care. - Assessed manufacturing costs and processes required for pilot-scale production of a Wound Stasis System. - At laboratory scale, synthesized in continuous flow the following Active Pharmaceutical Ingredients (APIs): Diphenhydramine, Diazepam, Lidocaine, Fluoxetine, Ibuprofen, Atropine, and Doxycycline. - Demonstrated continuous flow synthesis of Diphenhydramine, Diazepam, Lidocaine, and Fluoxetine using an integrated manufacturing platform. - Designed and tested drug product crystallization and formulation for Diphenhydramine, Diazepam, Lidocaine, and Fluoxetine in an integrated manufacturing platform. - Expressed protein therapeutics via fed-batch fermentation in both cell-free and cell-based systems.			

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Developed breadboard prototype device for treatment of intracranial hemorrhage using laser energy through the skull and tissues and demonstrated novel optical coupling technique to minimize peripheral tissue damage in porcine cadavers. ***FY 2014 Plans:*** - At laboratory scale, demonstrate continuous flow synthesis of the following APIs: Salbutamol, Ciprofloxacin, Azithromycin, Rufinamide, Etomidate, Triclabendazole, and Neostigmine. - Engage the FDA for input on Process Analytical Technologies (PAT) and current Good Manufacturing Process (cGMP) for Diphenhydramine, Diazepam, Lidocaine, Fluoxetine, Ibuprofen, Atropine, and Doxycycline. - Perform in vivo demonstration of transcranial photocoagulation of intracranial vessels in porcine model. - Perform in vivo demonstration of photo-induced vasospasm in intracranial vessels in porcine model. - Design and develop upstream and downstream components of miniaturized end-to-end manufacturing platform for protein therapeutics using cell-free and cell-based protein translation systems, including integration of protein expression and purification processes. ***FY 2015 Plans:*** - Develop novel continuous flow crystallizer, miniaturized reactors, and chemically compatible pumps for integration into a compact end-to-end manufacturing platform for the following APIs: Diphenhydramine, Diazepam, Lidocaine, Fluoxetine, Ibuprofen, Atropine, Doxycycline, Salbutamol, Ciprofloxacin, Azithromycin, Rufinamide, Etomidate, Triclabendazole, and Neostigmine. - Demonstrate continuous flow synthesis, crystallization, and formulation for Ciprofloxacin, Azithromycin, Rufinamide, Etomidate, Triclabendazole, and Neostigmine, in an integrated manufacturing platform. - Engage the FDA for input on PAT and cGMP for Ciprofloxacin, Azithromycin, Rufinamide, Etomidate, Triclabendazole, and Neostigmine. - Develop novel cell-free protein synthesis techniques using miniaturized bioreactors and microfluidics technologies. - Demonstrate end-to-end manufacturing of two protein therapeutics in a miniaturized platform, including the integration of protein expression and purification processes. - Engage the FDA for input on PAT and cGMP for protein therapeutics. - Design end-to-end manufacturing process in a miniaturized and integrated platform for an additional four protein therapeutics. - Test prototype device during in vivo pre-clinical studies for treatment of intracranial hemorrhage using laser energy through skull and tissues, and engage with the FDA on design and execution of these studies to meet FDA requirements.			
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, metabolic pathways, or physiological function in order to produce an image of diagnostic utility and performance. The goal of	4.216	8.000	6.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
this thrust is 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. Finally, this thrust will allow safe, non-invasive to minimally 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 2013 Accomplishments:*** - Measured the Quantum Orbital Resonance Spectroscopy (QORS) effect using the most sensitive experimental techniques to date. - Tested competing theoretical models for the physical basis of the QORS effect, and quantified the degree of hyperpolarization achieved under varying field strength, orbital angular momentum (OAM) charge, and beam array size. ***FY 2014 Plans:*** - Design and fabricate blazed, stacked, diffractive x-ray optics for integration into a pre-clinical imaging prototype. - Design and test imaging and validation protocols for pre-clinical imaging prototype. - Develop electrophysiological methods for simultaneous recording of multiple levels of abstraction in cortical/subcortical targets. - Identify candidate approaches for real-time analysis and monitoring of brain activity during performance of behavioral tasks. ***FY 2015 Plans:*** - Investigate advanced imaging technologies, such as three-photon fluorescence imaging, that will enable single neuron spatiotemporal resolution of deep brain regions. - Demonstrate proof of concept for achieving single neuron spatiotemporal resolution for recording spiking activity from 10^5 neurons in the cortex. - Investigate new indicators and effectors for single neuron spatiotemporal observation and control with high cell specificity.			
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. Additionally, the device may be effective as a medical countermeasure against various chemical and biological (chem-bio) threat agents, such as viruses, bacteria, fungi, and toxins.	9.000	20.000	20.000

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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 2013 Accomplishments:*** - Developed a systems integration plan, conducted a user needs assessment, and designed the preliminary systems architecture incorporating component separation technologies. - Developed appropriate animal models, confirmed regulatory plan, and initiated the regulatory approval process for the integrated device. ***FY 2014 Plans:*** - Integrate biocompatible high-flow fluid manipulation and intrinsic separation technologies into a breadboard device for the treatment of sepsis. - Use feedback from initial animal model testing to inform the development of an integrated device for additional safety and efficacy studies in a large-animal sepsis model. - Proceed with regulatory approval process and initiate plan for investigational device exemption submission. ***FY 2015 Plans:*** - Manufacture a prototype device that integrates label-free separation technologies, high-flow fluidic architectures, and non-thrombogenic coatings for testing. - Evaluate the efficacy of the label-free separation technologies in a small-animal model. - Refine the prototype device design based on animal testing results to inform development of a standalone benchtop integrated device. - Perform safety and efficacy studies in a large-animal sepsis model. - Initiate regulatory approval submission package with safety and efficacy data.			
Title: Warrior Web ***Description:*** Musculoskeletal injury and fatigue to the warfighter caused by dynamic events on the battlefield not only impact 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	12.150	12.000	8.992

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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
into current soldier systems. Because this sub-system will be compliant and 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 system is planned to weigh no more than 9kg and require no more than 100W of external power. Allowing the warfighter to perform missions with reduced risk of injuries will have immediate effects on mission readiness, soldier survivability, mission performance, and the long-term health of our veterans. ***FY 2013 Accomplishments:*** - Completed injury assessment and component technology integration into open source biomechanical model. - Completed initial verification and validation of component technologies in military environments. - Conducted preliminary reviews of individual component technologies (e.g., energy, actuation) to assess whether they can be integrated to meet Warrior Web performance requirements. ***FY 2014 Plans:*** - Leverage open source biomechanical model to iterate design. - Complete development of component technologies based on results of preliminary component technology reviews and government testing. - Initiate design of full Warrior Web system. ***FY 2015 Plans:*** - Conduct preliminary review of full Warrior Web designs and refine approach as necessary. - Finalize open source biomechanical models to be leveraged for the Warrior Web system evaluation. - Mature full design of Warrior Web system and continue parallel technology development. - Initiate verification and validation of prototype Warrior Web system via soldier tests in military environments.			
Title: Pathogen Defeat ***Description:*** Pathogens are well known for the high rate of mutation that enables them to escape drug therapies and primary or secondary immune responses. The Pathogen Defeat thrust area will provide 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 2013 Accomplishments:*** - Developed a platform to reproducibly demonstrate the evolutionary pathway of a virus under multiple selective pressures. - Validated algorithms' abilities to predict viral evolution in the presence of one or multiple pressures.	13.221	14.617	4.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602115E / *BIOMEDICAL TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Predicted location(s) and nature of genetic mutation(s) responsible for antiviral failure in a cell culture model. - Predicted number of viral generations necessary for the acquisition of antiviral resistance in a cell culture model. - Demonstrated that the in vitro evolution platform accelerates evolution of drug resistance or immune escape. ***FY 2014 Plans:*** - Predict location of genetic mutation(s) responsible for failure of a monoclonal antibody to neutralize a virus. - Demonstrate that the in vitro bioreactor can be used to predict alteration in cell tropism. - 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. - Focus on host species jumping, through development of predictive algorithms for receptor usage and entry. - Develop a hand-held device for rapid identification of microbial organisms, including development of diagnostic panels to be integrated into a modular, single-use microfluidics card. ***FY 2015 Plans:*** - Test predictive capabilities of algorithms using real-world samples of viral isolates. - Field test hand-held device for transition to forward-deployed troops for diagnostic purposes.			
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 functional and/or structural changes that occur in the human brain during the formation of distinct new memories, and to correlate those changes with subsequent recall of those memories during performance of behavioral tasks. This program will also develop neural interface hardware for monitoring and modulating neural activity responsible for successful memory formation in a human clinical population. The ultimate goal is identification of efficacious therapeutics or other therapies that can bypass and/or recover the neural functions underlying memory, which are often disrupted as a consequence of TBI. This program is leveraging research conducted under the Human Assisted Neural Devices effort in Program Element 0601117E, Project MED-01. ***FY 2014 Plans:*** - Identify neural codes underlying optimal memory formation. - Optimize electrodes for chronic, indwelling recording and stimulation. ***FY 2015 Plans:***	-	8.000	9.700

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602115E / *BIOMEDICAL TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Identify commonalities of neural codes underlying memory formation. - Identify distinctions between neural codes underlying different classes of memories. - Identify expert memory codes for the formation of memory associations between pairs of elements (e.g., objects, locations, actions). - Develop portable computational device with integrated computational model of human memory formation. - Demonstrate task-specific improvement/restoration of memory performance in a memory task via hippocampal stimulation.			
Title: Neuro-Adaptive Technology ***Description:*** Building upon technologies developed under the Military Medical Imaging program budgeted in this project, the Neuro-Adaptive Technology program will explore and develop advanced technologies for real-time detection and monitoring of neural activity. One shortcoming of today's brain functional mapping technologies is the inability to obtain real-time correlation data that links neural function to human activity and behavior. Understanding the structure-function relationship as well as the underlying mechanisms that link brain and behavior is a critical step in providing real-time, closed-loop therapies for military personnel suffering from a variety of brain disorders. Efforts under this program will specifically examine the networks of neurons involved in Post-Traumatic Stress Disorder (PTSD), Traumatic Brain Injury (TBI), depression, and anxiety as well as determine how to best ameliorate these disorders. The objective for this program is to develop new hardware and modeling tools to better discriminate the relationship between human behavioral expression and neural function and to provide relief through novel devices. These tools will allow for an improved understanding of how the brain regulates behavior and will enable new, disorder-specific, dynamic neuro-therapies for treating neuropsychiatric and neurological disorders in military personnel. Technologies of interest under this thrust include devices for real-time detection of brain activity during operational tasks, time synchronized acquisition of brain activity and behavior, and statistical models that correlate neural activity with human behavioral expression. ***FY 2015 Plans:*** - Develop tests that activate key brain subnetworks for each functional domain. - Develop computer algorithms/programs to automatically merge elements of multimodal brain activity across time/space. - Create statistical computational models of brain activity and corresponding behavior to support the neurophysiology of new therapeutic systems. - Train decoders on a subset of domains and cross-validate on novel scan, record, and stimulate data. - Develop hardware interface stability, biocompatibility, and motion correction for recording neural activity. - Demonstrate three-dimensional, single-cell-resolution acquisition of real-time brain activity in large volumes of neural tissue. - Submit initial, novel devices for regulatory approval.	-	-	21.000
Title: Prosthetic Hand Proprioception & Touch Interfaces (HaPTIx)	-	-	7.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: Wounded warriors with amputated limbs get limited benefit from recent advances in prosthetic-limb technology because the user interface for controlling the limb is low-performance and unreliable. Through investments in the DARPA Reliable Neural-Interface Technology (RE-NET) program, novel interface systems have been developed that overcome these issues and are designed to last for the lifetime of the patient. The goal of the Prosthetic Hand Proprioception & Touch Interfaces (HaPTIx) program is to create the first bi-directional (motor & sensory) peripheral nerve implant for controlling and sensing advanced prosthetic limb systems. With a strong focus on transition, the HaPTIx program will create and transition clinically relevant technology in support of wounded warriors suffering from single or multiple limb loss. ***FY 2015 Plans:*** - Develop and demonstrate advanced algorithms to control prosthetic limbs using signals extracted from thin-film longitudinal intrafasicular electrodes (tfLIFE), Utah Slant Electrode Array (USEA), and other commercially available or newly developed electrodes. - Develop and demonstrate micro-stimulation interface technologies that provide reliable signals into the peripheral and/or central nervous system for closed-loop prosthetic control. - Conduct clinical trials to restore lost sensation such as touch and proprioception to patients suffering from various forms of neuropathy or following amputation. - Develop and demonstrate micro-surgical techniques to increase targeted muscle reinnervation (TMR) of residual nerve fibers by separating fascicles, introducing growth factors, and/or conducting small muscle transfers. - Perform safety and efficacy testing of novel implantable interface technology which capture motor control signals and provide electrical sensory stimulation through the peripheral nervous system. - Support researchers preparing for Food and Drug Administration (FDA) investigational device exemption (IDE) application submissions in order to progress to clinical trials.			
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. ***FY 2013 Accomplishments:***	15.790	10.000	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrated neural control of arms with visual closed-loop feedback by spinal cord injured patients. - Demonstrated safety and stability of sensory feedback over multiple months to support use in human research participants. - Completed majority of FDA requirements, with additional human take-home trials and durability testing remaining, to gain commercial transition of non-invasively controlled prosthetic arm system. ***FY 2014 Plans:*** - Conduct 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. - Continue human quadriplegic patient trials demonstrating longevity of cortical control.			
Title: Detection and Computational Analysis of Psychological Signals (DCAPS) ***Description:*** The Detection and Computational Analysis of Psychological Signals (DCAPS) program developed automated information systems that identify group and individual trends indicative of post-traumatic stress disorder (PTSD) and anomaly detection algorithms that identify emerging physical and psychological crises. These tools 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. Furthermore, users will opt-in prior to using the DCAPS tools, ensuring controlled access to personally identifiable information. The program developed partnerships with key DoD organizations working in this area and transition activities are underway with the Veterans Affairs Center for Innovation and the Defense Suicide Prevention Office. ***FY 2013 Accomplishments:*** - Operationalized and hardened system software and obtained approvals to conduct user trials. - Performed user trials of mobile psychological health and telehealth applications in coordination with transition partners. - Modified and optimized mobile psychological health and telehealth applications based on the results of user trials.	7.100	-	-
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. The program developed approaches to counter any natural or man-made pathogen within one week. This included 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 resulted in reducing the traditional drug development cycle timeframe.	1.107	-	-

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
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C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Continued study to demonstrate 95% survival after exposure to lethal levels of an unknown pathogen in two animal models. - Identified neutralizing antibodies against newly emerging infectious diseases. - Identified genes and pathways in mouse and human peripheral blood mononuclear cells (PBMCs) that differ in inflammation models with the goal of leveraging these targets to treat and prevent inflammation.			
Title: Reliable Neural-Interface Technology (RE-NET) ***Description:*** Wounded warriors with amputated limbs do not yet benefit from recent advances in prosthetic-limb technology because the interfaces used to extract limb-control information are low-performance and unreliable. The Reliable Neural-Interface Technology (RE-NET) program developed 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. The RE-NET program also developed and demonstrated a novel interface system that overcame the leading causes of neural interface degradation and failure. Through this focus on reliability, the RE-NET program enabled patient access to clinically relevant technology, improving the lives of wounded warriors suffering from single or multiple limb loss. The effort continues under the HaPTIx program contained in this project. ***FY 2013 Accomplishments:*** - Developed and demonstrated advanced decoding algorithms which capture electromyography signals from the residual muscles in human amputees to provide simultaneous control of prosthetic limb joints. - Demonstrated amputee control of lost-limb finger-digits through successful decode of motor signals captured from residual nerve implantation of the Utah Slant Electrode Array (USEA). - Demonstrated a small implantable RF-powered electronics package capable of amplifying, processing, and wirelessly transmitting electromyography-based motor-control signals, such as those involved with targeted muscle reinnervation (TMR) and microTMR. - Commenced studies in collaboration with Walter Reed Army Medical Center through the Uniformed Health Services University using clinical-grade DARPA RE-NET-supported peripheral-interface technologies that capture motor-control intent from endogenous nerves and muscle tissue.	10.150	-	-
Accomplishments/Planned Programs Subtotals	98.097	114.790	112.242

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

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E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*							
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
Total Program Element	-	348.530	399.597	334.407	-	334.407	339.844	336.689	339.393	359.413	-	-
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	-	85.540	72.028	39.800	-	39.800	54.598	50.746	77.406	78.746	-	-
IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*	-	169.595	189.238	187.925	-	187.925	200.009	204.404	204.788	206.128	-	-
IT-04: *LANGUAGE TECHNOLOGY*	-	59.650	70.482	39.333	-	39.333	50.223	81.539	57.199	74.539	-	-
IT-05: *CYBER TECHNOLOGY*	-	33.745	67.849	67.349	-	67.349	35.014	-	-	-	-	-

The FY 2015 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 Technology 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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*

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 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	392.421	413.260	393.462	-	393.462
Current President's Budget	348.530	399.597	334.407	-	334.407
Total Adjustments	-43.891	-13.663	-59.055	-	-59.055
• Congressional General Reductions	-0.519	-0.663			
• Congressional Directed Reductions	-40.734	-15.000			
• Congressional Rescissions	-	-			
• Congressional Adds	10.000	2.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.464	-			
• SBIR/STTR Transfer	-10.174	-			
• TotalOtherAdjustments	-	-	-59.055	-	-59.055

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004 and directed reductions, sequestration adjustments, reprogrammings, and the SBIR/STTR transfer offset by Congressional adds.

FY 2014: Decrease reflects congressional reductions for program growth, the section 8023 FFRDC reduction, offset by an increase to the Plan X program.

FY 2015: Decrease reflects the completion of the BOLT program in the Language Technology Project (IT-04) in addition to the ending of the Advanced Vehicle Manufacturing programs in Project IT-02 (Meta and IFab).

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	Project (Number/Name) IT-02 / *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
IT-02: *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*	-	85.540	72.028	39.800	-	39.800	54.598	50.746	77.406	78.746	-	-

The FY 2015 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Power Efficiency Revolution For Embedded Computing Technologies (PERFECT)	27.370	38.337	33.800

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 and data placement to provide the required embedded system processing power efficiency.

FY 2013 Accomplishments:
- Discovered power kernels for embedded DoD applications, including ISR and encryption capabilities.
- Established initial simulation infrastructures for evaluating temporal and power efficiency for DoD embedded subsystems.
- Developed theoretical near threshold voltage and resiliency trade-offs for power efficiency.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-02 / *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Identified 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. ***FY 2015 Plans:*** - Incorporate test chip results - circuit, architecture, communication, power management, 3D - for design optimization and simulation refinement for continuing architectural development efforts. - Develop compiler algorithms supporting communication- avoiding optimization, concepts for optimizing parallel codes and language-based auto-tuning. - Deliver system-level integrated analytical modeling methodology and software analysis toolset for cross-layer, energy-constrained resilience optimization, processor, memory, and energy-reliability trade-offs. - Publically release new hardware description language and modeling/simulation infrastructure incorporating the evaluation and development of algorithms, specializers, hardware architectures, and resiliency techniques.			
Title: Cortical Processor ***Description:*** Capturing complex spatial and temporal structure in high-bandwidth, noisy, ambiguous data streams to meet DoD's needs cannot be achieved even by state-of-the-art signal/image analysis systems. However, there is a processing structure in nature, the mammalian neocortex, that efficiently captures spatial and temporal structure and routinely solves the most difficult recognition problems in real-time and is a general purpose structure for a range of sensor data processing and motor control execution. The Cortical Processor program will leverage simplified models of known cortical operation to develop a new processor architecture that is optimized for running a family of algorithms known as Hierarchical Temporal Memory (HTM), providing new levels of performance and capabilities to a broad range of data recognition problems. HTM models map well to simple, massively parallel, signal processor arrays and a cortical processor leveraging advances in dense memory structures on a Complementary Metal-Oxide-Semiconductor (CMOS) chip running at a few watts can perform orders of magnitude larger tasks than an HTM system simulated by commercial efforts on large data-center clusters. With certain specialized circuits, several orders of magnitude improvement in throughput and efficiency will be possible with the cortical processor, enabling a wide range of powerful, ultra-low power, embedded applications.	-	-	6.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Executing large HTM models on modest-sized embedded platforms will transform the DoD's ability to convert huge quantities of data into actionable information. By augmenting tactical sensor systems on the battlefield with the new functionalities of predictive analyses and anomaly detection, this technology will have a major impact on the abilities of autonomous vehicles, robots, and UAVs. The Cortical Processor will adapt to changing environments while reducing the need for a man in-the-loop, providing entirely new capabilities that cannot be achieved with today's commercial hardware. This technology will enable more complex missions, particularly for surveillance systems and portable analytics and knowledge extraction from vision sensors and multi-model integration for the DoD and intelligence communities. Basic research for the program is budgeted in PE 0601101E, Project CCS-02. ***FY 2015 Plans:*** - Specify cortical processor system architecture and generate performance and power estimates. - Initiate design of modular HTM coprocessor/accelerator chip. - Simulate selected transition of DoD application(s) using an HTM algorithm approach demonstrating the ability to learn and adapt.			
Title: META ***Description:*** The goal of the META program is to develop novel design flows, tools, and processes to enable a significant improvement in the ability to design complex defense systems that are verified by virtual testing. 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 ---compression in the time to develop and field complex defense and aerospace systems. ***FY 2013 Accomplishments:*** - Developed 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. - Transmitted 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.	36.169	20.691	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-02 / *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Began 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:*** - Conclude 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. - Conduct preliminary developmental Beta testing and integrated demonstration testing for the expanded META tool suite including expanded capability features. - Conduct META tool transition activity to commercial Product Lifecycle Management (PLM) tool suites. - Transition META software tool suite and associated technology to the Digital Manufacturing and Design Innovation Institute (DMDII) through the use of co-funded research and formal technology transition activities for industry use.			
Title: Instant Foundry Adaptive Through Bits (iFAB)	22.001	13.000	-
Description: 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--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 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 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 Foundry for infantry fighting vehicles (IFV) is the Joint Manufacturing and Technology Center (JMTC) at the Rock Island Arsenal (RIA). ***FY 2013 Accomplishments:*** - Conducted a preliminary design review and critical design review (CDR) for the iFAB Foundry.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Matured and integrated foundry infrastructure tools developed under iFAB, including manufacturing feedback and process planning. - Developed foundry infrastructure tools to assess assembly processes and requirements. - Upgraded the RIA final assembly facility of the iFAB Foundry, and installed equipment for the first FANG challenge for an amphibious IFV drivetrain and mobility subsystem. - Tested 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. - Provided manufacturability feedback to the META design process in support of the first FANG challenge for an IFV drivetrain and mobility subsystem. - Configured the iFAB foundry to build the winning drivetrain and mobility subsystem design from the first FANG Challenge. ***FY 2014 Plans:*** - Build and test the winning drivetrain and mobility subsystem design from the first FANG Challenge. - Provide manufacturability feedback to the META design process in support of the tool validation testing. - Transition iFAB software tool suite and associated technology to the Digital Manufacturing and Design Innovation Institute (DMDII) through the co-funded research and formal technology transition activities for industry use. - Transition all physical infrastructure for the iFAB Foundry final assembly node at RIA to JMTC.			
Accomplishments/Planned Programs Subtotals	85.540	72.028	39.800

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 2015 Defense Advanced Research Projects Agency			Date: March 2014
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COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
IT-03: *INFORMATION ASSURANCE AND SURVIVABILITY*	-	169.595	189.238	187.925	-	187.925	200.009	204.404	204.788	206.128	-	-

The FY 2015 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 0603766E), 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 2013	FY 2014	FY 2015
Title: High Assurance Cyber Military Systems	16.064	23.117	29.000

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 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. 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 2013 Accomplishments:

- Performed static and dynamic baseline assessments of selected militarily relevant vehicles before any modifications were made, discovering significant vulnerabilities in all four program platforms.
- Developed initial techniques and built prototype tools to assist in the rapid creation of high-assurance embedded computing systems on a variety of vehicles, including domain-specific languages for building and configuring flight control software.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Constructed 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 verified full functional correctness for portions of a core operating system and targeted control-systems for selected vehicles. - Demonstrated required security properties that follow from correctness, specifically, non-transitive non-interference. ***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. ***FY 2015 Plans:*** - Formally verify full functional correctness for the extended core operating system and the automatically synthesized control systems for selected vehicles. - Demonstrate required security properties that follow from correctness for the extended core operating system and the automatically synthesized control systems. - 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 (VET) ***Description:*** 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 Accomplishments:*** - Defined the requirements for the three key program challenges: the discovery of likely attack scenarios, the design of program analysis tools, and the reliable execution of diagnostics on already-compromised systems. - Developed concept of operations, created example supply chain attack scenarios, presented initial program analysis approaches, and specified diagnostic tool functionality. - Identified 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:***	7.376	17.954	21.553

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop relevant application programming interfaces and define formal semantics for the programming languages to be analyzed. - Produce initial prototype attack scenario generation, program analysis, and diagnostic tools. - Produce initial set of challenge programs for use in a competitive evaluation. - Perform a competitive engagement between research and adversarial challenge performers to produce measurements of research progress against program metrics. ***FY 2015 Plans:*** - Improve the effectiveness of prototype tools through further competitive engagements. - Expand the set of challenge programs to explore more complex forms of malicious hidden functionality. - Conduct an integrated end-to-end software/firmware-vetting technology demonstration relevant to potential transition partners.			
Title: Mission-oriented Resilient Clouds (MRC)	23.500	21.571	16.892
Description: 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 can be amplified in cloud computing environments. MRC will address this risk 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 2013 Accomplishments:*** - Developed new behavior-based algorithms for detecting compromised machines. - Developed and demonstrated new resource allocation algorithms that maximize mission-effectiveness by allocating bandwidth and computing resources to higher priority tasks while avoiding the use of potentially compromised resources. - Validated the performance of new algorithms and protocols for high-assurance computing and data analysis in cloud computing systems. - Demonstrated a fault tolerant cloud computing environment that produces correct results when individual computing and network elements have been compromised or disabled. - Developed protocols for cloud monitoring and control that are tolerant of disruptions and intrusions, and validated performance on a commercial cloud.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Began first experiment to transition automated, distributed resource allocation algorithms to United States Pacific Command (USPACOM). ***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 adaptation of data replication in response to estimated and predicted attack levels. - Implement self-healing functionality for cloud applications. - Begin evaluating technologies in Defense Information Systems Agency (DISA) testbeds to facilitate transitions into DoD clouds. - Transition research product into USPACOM distributed computing environments. ***FY 2015 Plans:*** - Demonstrate automated construction of diverse, redundant network flow paths that maximize communication resilience in clouds. - Extend consensus protocols to work between diverse, virtualized clouds and measure improvements in mission resilience. - Produce and validate a network abuse detection and mitigation system that operates in software defined networks. - Develop and demonstrate hardened services through fine-grained memory access controls that determine what valid memory addresses are read or written to by each instruction in a program. - Complete transition of one or more technologies into operational use by DISA and USPACOM.			
Title: Active Cyber Defense (ACD) ***Description:*** The Active Cyber Defense (ACD) program will enable DoD cyber operators to fully leverage our inherent home field advantage when defending the DoD cyber battlespace. In the cyber environment, defenders have detailed knowledge of, and unlimited access to, the system resources that attackers wish to gain. The ACD program will exploit emerging technologies to facilitate the conduct of defensive operations that involve immediate and direct engagement between DoD cyber operators and sophisticated cyber adversaries. Through these active engagements, DoD cyber defenders will be able to more readily disrupt, counter, and neutralize adversary cyber tradecraft in real time. Moreover, ACD-facilitated operations should cause adversaries to be more cautious and should increase their work factor by limiting the success from their efforts. ***FY 2013 Accomplishments:*** - Developed initial system requirements and concept of operations. - Drafted test plans and test scenarios for prototype assessments and identified key technical metrics for evaluation. - Held coordination meetings with potential transition partners including NSA, U.S. Cyber Command, and others. ***FY 2014 Plans:***	5.300	12.500	16.328

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop techniques for countering adversary cyber tradecraft and implement in early prototype software applications. - Develop detailed system designs and design documentation. - Finalize test plans and perform initial evaluations of active cyber defense prototypes in exercises with transition partners. ***FY 2015 Plans:*** - Integrate technologies into complete prototypes and demonstrate capabilities to transition partners. - Perform final test and evaluation of integrated capabilities and obtain approval for operational deployment. - Support initial operational fielding of capability.			
Title: Clean-slate design of Resilient, Adaptive, Secure Hosts (CRASH)	28.502	27.536	16.600
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. ***FY 2013 Accomplishments:*** - Implemented a compiler that automatically produces diverse instantiations of a complete Linux operating system and demonstrated that the resulting operating system is resistant to standard attacks. - Demonstrated a novel form of moving target defense that employs several automatically constructed diverse implementations of the same algorithm. - Produced a tool that finds and fixes bugs and attendant security vulnerabilities in operating system and utility software. - Demonstrated roll-back and recovery on two production-scale applications with substantially reduced requirements for human involvement. - Developed technology to mitigate vulnerabilities found in widely used embedded systems such as telephones and printers and initiated efforts to transition the technology into commercial use. ***FY 2014 Plans:*** - Complete the implementation of two novel secure processors and operating systems and demonstrate the ability to resist all attacks mounted by a red-team. - Demonstrate the capability to wrap C2 software codes as a means to thwart cyber attack.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- 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. - Transition research products into one or more embedded systems and a secure router for military use. ***FY 2015 Plans:*** - Automatically produce diverse instantiations of one or more complete operating systems. - Deliver a web server that enables creation of secure web sites from untrusted code. - Deliver a web server and browser that enable creation of secure web applications from untrusted code. - Demonstrate policy-based application monitoring and hardware-assisted self-healing of multiple applications.			
Title: Rapid Software Development using Binary Components (RAPID) ***Description:*** The Rapid Software Development using Binary Components (RAPID) program will develop a system to identify and extract software components for reuse in new applications. The DoD has critical applications that must be ported to future operating systems. In many cases, the application source code is no longer available requiring these applications to continue to run on insecure and outdated operating systems, impacting operations. Advanced technology research for the program is budgeted in PE 0603760E, Project CCC-04. ***FY 2013 Accomplishments:*** - Developed an initial low level virtual machine translation engine. - Completed the initial implementation of the user interface. ***FY 2014 Plans:*** - Fully integrate technologies into a single architecture and standardize interfaces to enable partners to interoperate with the system. - Develop a single user interface that combines technical area views and supports mobile operation. ***FY 2015 Plans:*** - Develop new software component reuse capabilities to optimize application performance in realistic scenarios and enable an expanded concept of operations. - Implement new capabilities in modules designed to interoperate seamlessly with deployed RAPID prototype systems. - Integrate new modules into prototype RAPID systems deployed at transition partner sites and support initial operations.	2.049	8.198	13.396
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, and groups over hours, days, months, and years. ADAMS will	15.000	17.612	9.750

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
develop flexible, scalable, and highly interactive approaches to extracting actionable information from information system log files, sensors, and other instrumentation. ADAMS will integrate these anomaly detection algorithms to produce adaptable systems for timely insider threat detection. ***FY 2013 Accomplishments:*** - Refined and created techniques for detecting malicious insiders, delineated assumptions/conditions under which they are valid/ invalid, and specified their effective combination. - Created a comprehensive library of test data and quantified probabilities of detection and false alarm for anomalous non-threat and threat behaviors. - Developed technologies to manage the number of anomalies, focus computing resources on ambiguous results, and prioritize threats. - Demonstrated 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 incorporate such user feedback in decision loops for counter intelligence (CI) agents without highly specialized computer science knowledge. - Create the capability to incorporate direct CI agent feedback to improve coverage of threat types. - Develop and implement technology that is adaptable to a wide variety of organizational structures, workflows, and data sources. - Develop techniques to provide the evidence needed to initiate focused response activities. ***FY 2015 Plans:*** - Develop an integrated prototype anomaly/threat detection system suitable for rapid deployment in an operational environment. - Harden prototype and obtain DoD Information Assurance Certification and Accreditation Process approval for use on military networks. - Conduct and evaluate initial prototype in a large scale environment with operational partners.			
Title: Active Authentication* ***Description:*** *Previously funded in PE 0601101E, Project CYS-01. 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	6.489	13.100	8.025

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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 2013 Accomplishments:*** - Developed open application programming interfaces to allow the ready integration of third-party software and hardware biometrics. - Initiated development of an additional authentication platform suitable for deployment on DoD hardware. - Implemented multiple advanced authentication mechanisms in prototype systems potentially suitable for use on DoD networks. - Coordinated with U.S. Army Intelligence and Information Warfare Directorate for transition into Army biometric-enabled authentication platform. ***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 an authentication platform suitable for DoD use in collaboration with potential transition sponsors. - Initiate development of multiple authentication biometrics suitable for deployment on mobile hardware for potential use by the DoD. ***FY 2015 Plans:*** - Demonstrate multiple authentication biometrics suitable for deployment on mobile hardware for potential use by the DoD. - Prove flexibility of underlying prototype platform by creating an additional authentication platform suitable for DoD. - Prototype an authentication platform suitable for use on mobile hardware in collaboration with potential transition sponsors.			
Title: Integrated Cyber Analysis System (ICAS) ***Description:*** The Integrated Cyber Analysis System (ICAS) program will develop techniques to automatically discover 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. ICAS will develop technologies to allow for the correlation of interactions and behavior patterns across all system data sources and thereby rapidly uncover aberrant events and detect system compromise. This includes technologies for automatically representing, indexing, and reasoning over diverse, distributed, security-related data and system files. ***FY 2013 Accomplishments:*** - Developed an approach for transforming log/system file formats into a unified schema as the basis for an actionable view of enterprise operational security.	3.044	10.000	6.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Conceptualized indexing schemes specialized to system files/security data and suitable for use across federated enterprise architectures. - Identified potential transition partners within DoD and established operational requirements. ***FY 2014 Plans:*** - Develop and implement algorithms for automatically identifying and quantifying specific security risks on enterprise networks. - Conduct initial technology demonstrations including automatic indexing of data sources, common language integration, and reasoning across federated databases. - Complete alpha versions of applications which meet all program objectives and test in coordination with transition partners. - Integrate, evaluate, and optimize algorithms via testing against attacks/persistent threats provided by transition partners. ***FY 2015 Plans:*** - Complete fully functional beta versions of the applications with operational stability suitable for testing at transition partner locations. - Harden and deploy solutions to transition partner networks throughout the DoD.			
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 to enable 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 2013 Accomplishments:*** - Performed independent, adversarial assessment of the effectiveness of technologies to prevent communication localization and detection. - Demonstrated two developmental technologies for anonymous web communications which are much more difficult for an adversary to detect or block. - Demonstrated an initial field programmable gate array implementation of fully homomorphic encryption offering an order of magnitude performance improvement over optimized software implementations.	17.680	15.150	4.066

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Performed independent benchmarks of fully homomorphic encryption, garbled-circuit secure multiparty computation, and secret-sharing secure multiparty computation. - Demonstrated two orders of magnitude improvement in performance of fully homomorphic encryption. ***FY 2014 Plans:*** - Integrate decoy routing, parallelized group messaging, dynamic traffic camouflage, and rendezvous strategy technologies into common internet browsing applications. - Conduct the final independent, adversarial assessment of the effectiveness of 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. - Demonstrate an additional two orders of magnitude improvement in the performance of fully homomorphic encryption. - Refine field programmable gate array implementation of fully homomorphic encryption to yield a further order of magnitude performance improvement over optimized software implementation. ***FY 2015 Plans:*** - Demonstrate safe, anonymous internet communications applications such as web access, Voice over Internet Protocol (VOIP), and streaming video, at scale. - Further optimize field programmable gate array and software implementations of fully homomorphic encryption to double performance over prior implementations.			
Title: Logan ***Description:*** 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 Accomplishments:*** - Formulated CNA techniques and implemented these in initial software routines. - Developed manual prototypes for operational transition. ***FY 2014 Plans:*** - Automate and test prototypes in conjunction with transition partner. - Optimize and harden prototypes and complete transition. ***FY 2015 Plans:***	6.000	9.803	4.697

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Transition automated system for operational implementation.			
Title: Integrity and Reliability of Integrated CircuitS (IRIS)	18.500	1.000	-

Description: Integrated circuits (ICs) are core components of most 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.

The Integrity and Reliability of Integrated CircuitS (IRIS) program seeks to develop techniques that will provide electronic system developers the ability to validate the function of digital, analog and mixed-signal ICs non-destructively, given limited data about the chip's detailed design specifications. These techniques will include advanced imaging for identification of functional elements in deep sub-micrometer Complementary Metal-Oxide Semiconductor (CMOS) circuits, as well as computational methods to deal with the extremely difficult problem of determining device connectivity.

Finally, the IRIS program will develop innovative methods 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 2013 Accomplishments:
- Demonstrated the ability to identify design primitives (transistors, capacitors, resistors), memory elements and interconnects through non-destructive imaging, and derived a net-list from these components.
- Demonstrated functional derivation of modified digital and mixed-signal ICs at the 45 nm CMOS node.
- Demonstrated reliability derivation from reduced sample sizes of modified ICs.
- Demonstrated non-destructive techniques for functional analysis of a digital IC.
- Demonstrated tools for functional derivation from third-party IP (Intellectual Property) blocks for both Application Specific Integrated Circuits (ASICs) and Field Programmable Gate Arrays (FPGAs).
- Developed digital and mixed-signal test articles appropriate for testing techniques for identifying unintended circuits and circuit functions.

FY 2014 Plans:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Exercise completed methods for non-destructive imaging, circuit extraction and functional derivation. - Demonstrate methods for reliability analysis for improved accuracy, functionality and efficacy.			
Title: Supply Chain Hardware Intercepts for Electronics Defense (SHIELD)	-	5.000	16.500
Description: Counterfeit electronic parts are becoming ubiquitous, and pose a threat to the integrity and reliability of DoD systems. Detection of counterfeit components by current means is expensive, time-consuming, and of limited effectiveness. Maintaining complete control of the supply chain using administrative controls incurs substantial costs and has limitations. Current methods of detection involve a wide variety of techniques ranging from functional testing to physical inspections which may still miss certain classes of counterfeits. There have also been attempts by the semiconductor market to protect electronic components through the use of technology embedded in the component or its packaging. However, most methods are specific to a manufacturer's component and as such address only those issues deemed critical to that manufacturer. Some methods can be circumvented, or require slow, expensive, off-site forensic analysis to verify authenticity. The Supply Chain Hardware Intercepts for Electronics Defense (SHIELD) program, leveraging and expanding on previous activities in the IRIS program, will develop a technology capable of confirming, at any time, the authenticity of once-trusted parts, even after they have transited a complex global supply chain. SHIELD will prevent counterfeit component substitution by incorporating a small, inexpensive additional silicon chip ("dielet") within the Integrated Circuit (IC) package. The dielet will provide a unique and non-clonable ID as well as anti-tamper features. The microscopic-size dielet embedded in the electronic component packaging will be inductively powered and scanned by an authentication induction coil brought into very close proximity to the packaged chip, thus allowing for verification of chip identity. ***FY 2014 Plans:*** - Develop behavioral models for SHIELD performance and power consumption. - Establish server communication protocols, encryption standards, network architectures. - Design test sites for technology, surrogate dielet structures for package tests. - Define process modifications needed to accommodate SHIELD insertions. ***FY 2015 Plans:*** - Develop technologies to allow secure key and ID storage and prevent tampering with the dielet. - Design a compact encryption engine that enables a very small, low power, and low-cost dielet. - Define a power and communication inductive coil protocol. - Simulate and prototype dielet package-insertion techniques for placing SHIELD on product.			
Title: Protecting Cyber Physical Systems (PCPS)	-	-	9.525

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-03 / *INFORMATION ASSURANCE AND SURVIVABILITY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: The Protecting Cyber Physical Systems (PCPS) program will create new technologies for ensuring the availability and integrity of cyber physical systems. The near-ubiquitous use of embedded computing in commercial, industrial, and medical devices, the emergence of software defined networking, and the importance of automatic control to U.S. civilian and military critical infrastructure make this a national security issue. PCPS will develop technologies to monitor heterogeneous distributed industrial control system networks, detect anomalies that require rapid assessment, and mitigate sensor spoofing and denial of service attacks. Mechanisms to ensure the integrity of remote firmware updates and mitigate attacks for which wireless interfaces provide a vector will also be developed. PCPS technologies will transition to military installations and commercial industry. ***FY 2015 Plans:*** - Develop technologies to monitor heterogeneous distributed industrial control system networks, detect anomalies that require rapid assessment, and mitigate sensor spoofing and denial of service attacks. - Create mechanisms to ensure the integrity of remote firmware updates. - Develop approaches for mitigating the risks associated with wireless interfaces.			
Title: Active-Reactive Cyber Systems (ARCS) ***Description:*** The Active-Reactive Cyber Systems (ARCS) program will develop technologies to enable hosts, systems, and networks to actively sense for threats and to dynamically react to attacks. Current cyber defense technologies are statically configured to satisfy a complex set of engineering trade-offs and are rarely optimized for the dynamic environments in which they are deployed. ARCS technologies will use organic sensors, remote instrumentation, and other sources of cyber situation awareness information to continuously optimize cyber defenses. Host and network management and control technologies will be developed that enable systems to fight through cyber attack and provide essential mission services by repurposing resources to critical services, repairing damaged resources, and utilizing degraded resources. ARCS software agents will protect data stores by implementing dynamic access controls that consider user and program authorization within the context of the cyber situation and network defense posture. ***FY 2015 Plans:*** - Develop techniques that use organic sensors, remote instrumentation, and other sources of cyber situation awareness information to continuously optimize cyber defenses. - Develop host and network management and control technologies that enable systems to fight through cyber attack and provide essential mission services. - Develop software agents that implement dynamic access controls that consider user and program authorization within the context of the cyber situation and network defense posture.	-	-	8.500
Title: Adaptable Information Access and Control (AIAC)	-	-	7.093

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-03 / *INFORMATION ASSURANCE AND SURVIVABILITY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: The Adaptable Information Access and Control (AIAC) program will create the capability to dynamically, flexibly, and securely share highly selective information across enterprise boundaries. In the civilian sphere, there is a recognized need for technologies that limit the sharing of information between commercial entities and U.S. government agencies to the greatest extent possible consistent with national security requirements. Similarly, the U.S. military is increasingly involved in humanitarian operations that require highly selective sharing of data with a heterogeneous mix of allies, coalition partners, and other stakeholders. AIAC will create confidentiality, privacy, multi-level security, discretionary access control, and policy engine technologies to allow tailored access to a specific datum but not an entire database/file system/corpus. AIAC is timely due to recent progress on cryptographic techniques such as homomorphic encryption and secure multiparty computation. Additional technologies that will be developed and incorporated include automated policy-driven releasability assessment and redaction, tactical obfuscation, and time-limited-access controls. The program will address the diverse and stringent legal and ethical requirements related to security, privacy, authentication, authorization, auditing, monitoring, access, and control encountered in both civilian and military environments. To facilitate deployment, AIAC technologies will be designed to work with the virtualization, cloud computing, and software-defined networking technologies now widely used in both civilian and military environments. ***FY 2015 Plans:*** - Formulate access control schemes appropriate for diverse civilian, intelligence, law enforcement, and coalition use cases with particular focus on privacy-preserving analytics. - Architect an access control policy engine for seamless interoperability with common computing and networking infrastructure software. - Create technologies for confidentiality, privacy, multi-level security, discretionary access controls, automated policy-driven releasability assessment and redaction, tactical obfuscation, computing on encrypted data, and time-limited-access controls.			
Title: Cyber Genome ***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 2013 Accomplishments:*** - Developed techniques to automatically and reliably extract forensically-meaningful traits such as authorship, compiler, toolkit, and obfuscation techniques. - Enhanced co-clustering and binary analysis techniques to enable the automatic identification of re-used components.	15.949	6.697	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-03 / *INFORMATION ASSURANCE AND SURVIVABILITY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Developed operationally relevant use case test scenarios with transition partners and conducted initial use case validation tests. - Implemented prototypes and evaluated their effectiveness on realistic malware samples. - Executed an MoA with the FBI to evaluate the performance of the automated malware analysis tools on operational data. ***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: Cyber Fast Track ***Description:*** The Cyber Fast Track program created more flexible, responsive methods for securing computing systems that operate in challenging environments and reduced security risk without requiring lengthy development cycles. Under Cyber Fast Track, small agile teams worked under rapid development cycles to create cyber security applications. ***FY 2013 Accomplishments:*** - Expanded outreach to customers/transition sponsors. - Completed efforts and transitioned technologies to multiple DoD agencies.	4.142	-	-
Accomplishments/Planned Programs Subtotals	169.595	189.238	187.925

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 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	Project (Number/Name) IT-04 / *LANGUAGE TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
IT-04: *LANGUAGE TECHNOLOGY*	-	59.650	70.482	39.333	-	39.333	50.223	81.539	57.199	74.539	-	-

The FY 2015 OCO Request will be submitted at a later date.

A. Mission Description and Budget Item Justification

The Language Technology 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. 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. Warfighters need speech-to-speech translation systems that enable communication with local populations, especially two-way (foreign-language-to-English and English-to-foreign-language) translation. In addition, 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, information extraction, and other language analytic systems contribute to the development of critical intelligence and situational awareness. Technologies for translation of informal genres (online discussion groups, messaging, and telephone conversation) of voice and text, as well as capabilities to automatically collate, filter, synthesize, summarize, and present relevant information in near real-time will enhance situational awareness.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Broad Operational Language Translation (BOLT)	40.206	45.113	-
Description: The Broad Operational Language Translation (BOLT) program is enabling communication in informal and dialectal genres. Historically, foreign language translation technology was geared toward formal content, like broadcast media and newswire, but did not address informal or dialectal genres. BOLT is developing new approaches to automated language translation, human-machine multimodal dialogue, and language generation and applying these to informal genre such as online discussion groups, messaging, and telephone conversation. BOLT will leverage the strengths of statistical and rule-based approaches to form hybrid machine translation techniques that are more robust to linguistic dialectal variation; develop new techniques for modeling word relationships, functions, and context; and utilize syntactic and semantic patterns to fill in the linguistic gaps inherent in conversational language and to accelerate statistical learning. While Chinese and dialectal Arabic are the two languages addressed directly in BOLT, techniques developed for these two languages will have wide applicability to other languages and dialects. 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.			
FY 2013 Accomplishments: - Developed new and improved algorithms for translating two informal genres of Arabic and Chinese text, online discussion groups and messaging, and created annotated corpora for training and testing the algorithms.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-04 / *LANGUAGE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Developed methods for Egyptian dialectal Arabic that are applicable to all Egyptian Arabic informal genres and used these to develop databases, tools, and algorithms to translate Tunisian dialectal Arabic. - Developed algorithms for automatically assessing the degree of confidence in both the automatic speech recognition and machine translation hypotheses in a human-human dialogue system and specialized these to Arabic-English dialogue. - Developed enhanced automatic Arabic speech recognition techniques capable of handling garbled and ambiguous speech and words outside the vocabulary of the machine and integrated these into a robust bi-directional Arabic-English dialogue system. ***FY 2014 Plans:*** - Develop improved algorithms for translating two informal genres of Arabic and Chinese text, online discussion groups and messaging, to enable comprehension of colloquialisms and idiomatic speech and add a third genre, telephone conversation. - Use methods developed for Egyptian and Tunisian dialectal Arabic to create databases, tools, and algorithms for additional Arabic dialects. - Enhance bi-directional Arabic-English dialogue systems by incorporating topic modeling and exploiting cross-utterance context recognition. - Develop dialogue management techniques such as computer-moderated turn-taking to avoid divergence as an approach for improving the performance of bi-directional Arabic-English dialogue systems. - Complete the annotated corpora of Arabic and Chinese informal genre data by adding new dialects and enhance their utility by incorporating additional annotations. - Generalize Arabic dialectal databases, tools, and algorithms to make it straightforward to add Arabic dialects. - Work with transition partners to identify insertion opportunities and transition algorithms for translating informal genres of Arabic and Chinese.			
Title: Deep Exploration and Filtering of Text (DEFT) ***Description:*** 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 Accomplishments:*** - Developed initial methods and algorithms to derive meaning from context for words that may have implicit or hidden meanings and to extract and disambiguate events in a document or set of documents.	15.946	25.369	28.333

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-04 / *LANGUAGE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Implemented preliminary algorithms that use domain knowledge to infer implicit information from multiple facts and statements, answer questions, and generate hypotheses in domains of military interest. - Developed training data sets and queries for science and technology, human-behavioral-social-cultural, and asymmetric threat domains and performed evaluation experiments. - Designed new workflows in collaboration with end-users to enhance operational efficiency and effectiveness. ***FY 2014 Plans:*** - Develop methods and algorithms for reasoning about both explicitly and implicitly expressed opinions and beliefs, for extracting causal knowledge, and for finding hidden meaning based on anomalous usages and disfluencies in a document or set of documents. - Conduct performance evaluations on data sets related to event representation, anomaly detection, and inference. - Expand capabilities to additional application problems and domains in collaboration with end-users. - Demonstrate feasibility of deep extraction and filtering for selected end-user applications and transition initial sets of algorithms to end-users for enhanced workflows. ***FY 2015 Plans:*** - Develop technology for extracting belief, sentiment, and intent; for representing geo-spatial features and temporal events; and for inference, summarization, and alerting from a set of documents. - Integrate multiple complementary algorithms into a comprehensive and consistent functional suite to support end-user workflows and problems. - Transition algorithm suites and conduct effectiveness assessments at end-user sites.			
Title: Foreign Language Rapid Response (FLRR) ***Description:*** The Foreign Language Rapid Response (FLRR) program will develop the capability to rapidly construct human language technologies for foreign languages. Historically, exploiting foreign language materials required protracted effort and as a result systems exist only for languages in widespread use and in high demand. The military operates globally and frequently encounters less common low-resource languages for which no automated human language technology capability exists. FLRR technologies will identify the commonalities between a newly-encountered low-resource language and high-resource languages and will identify language universals to rapidly re-purpose existing language technologies to the low-resource language. This will enable the rapid creation of automated language technology systems for cross-language intelligence and strategic communications. ***FY 2015 Plans:*** - Identify the universal properties of language to serve as the basis for an extensible family of human language technologies. - Develop techniques for quantifying the linguistic similarity of language usage in diverse documents and media.	-	-	11.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-04 / *LANGUAGE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop semantic techniques for identifying the common topics, themes, and sentiment in a collection of snippets in diverse foreign languages. - Create a baseline toolkit to rapidly develop initial document triage capability for a new low-resource language document collection. - Develop techniques for learning language from conversation about the things and people in the immediate environment.			
Title: Robust Automatic Translation of Speech (RATS) ***Description:*** The Robust Automatic Transcription of Speech (RATS) program addressed conditions in which speech signals are degraded by distortion, reverberation, and/or competing conversation. Robust speech processing technologies 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 isolated and delivered 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 2013 Accomplishments:*** - Developed and implemented effective processing techniques for noisy environments, including speech activity detection, language identification, speaker identification, and keyword spotting. - Evaluated performance showing substantial progress on noisy and degraded speech signals from the program-generated data corpus. - Conducted tests of training systems on field-collected data and tested systems in realistic environments. - Established a relationship with Offutt AFB to obtain real data and perform testing on site at the user location.	1.998	-	-
Title: Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) ***Description:*** The Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) program developed and integrated 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 addressed this need by producing devices to convert such captured documents from Arabic into readable English in the field. MADCAT substantially improved applicable technologies, in particular document analysis and optical character recognition/ optical handwriting recognition. MADCAT integrated these improved technologies with translation technology and created prototypes for field trials. ***FY 2013 Accomplishments:*** - Transitioned tightly integrated technology prototypes to military and intelligence operations centers. - Trained and tested techniques on field-collected data.	1.500	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-04 / *LANGUAGE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Improved MADCAT technologies transcribing and translating field-collected handwritten, machine-printed, and mixed handwritten and machine-printed documents.			
Accomplishments/Planned Programs Subtotals	59.650	70.482	39.333

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 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	Project (Number/Name) IT-05 / *CYBER TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
IT-05: *CYBER TECHNOLOGY*	-	33.745	67.849	67.349	-	67.349	35.014	-	-	-	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: Plan X	20.796	37.919	41.619

Description: The 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 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 2013 Accomplishments:
- Mapped network topologies consisting of thousands of nodes derived from millions of traceroute outputs.
- Generated and validated cyber mission plans at operationally relevant scales and speeds.
- Created a cyber domain specific language with binding to existing operational tools and cyber warfare mission planning interface.
- Built initial range infrastructure supporting hundreds of nodes in a dynamic topology.

FY 2014 Plans:
- Release Plan X 1.0, including product launch and developer workshop.
- Coordinate development with operators from Air Force, Navy, Marine Corps, and Army cyber components and U.S. Cyber Command.
- Develop commander, planner, and operator views for the user interface.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-05 / *CYBER TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Create automated network simulation technology to model the cyber battlespace, generate cyber warfare mission plans, and script cyber warfare missions using domain specific languages. ***FY 2015 Plans:*** - Create runtime environment and platforms capable of automatically deploying cyber warfare mission scripts. - Release Plan X 2.0, including product launch and developer workshop. - Demonstrate cyber battle damage assessment. - Demonstrate capabilities by developing complex cyber training missions and employ system in a large-scale exercise (e.g., Cyber Flag).			
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 2013 Accomplishments:*** - Developed approaches for mapping high-level formal software verification problems into user-driven simulations. - Developed techniques for inferring specification and coding errors from the solutions to these simulations and for automatically generating the appropriate annotations to aid formal verification. - Developed web-based infrastructure to support large scale formal software verification workflows. - Developed and tested the concept on a moderately-sized computer program consisting of thousands of lines of source code. ***FY 2014 Plans:*** - Develop five web-based interactive computer simulations based on mapped high-level software specifications and codes. - Launch and maintain public web site to attract the widest possible base for crowd-sourcing formal verifications. - Apply simulations to large Java and C computer programs consisting of hundreds of thousands of lines of source code. - 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. ***FY 2015 Plans:*** - Refine simulations to make them accessible to a large set of non-specialists. - Augment simulations to handle very large Java and C computer programs consisting of millions of lines of source code. - Enhance public web site to include these new simulations.	12.949	14.680	8.898

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602303E / *INFORMATION & COMMUNICATIONS TECHNOLOGY*	**Project (Number/Name)** IT-05 / *CYBER TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Assess effectiveness of the new simulations on the large-sized code targets.			
Title: Cyber Grand Challenge (CGC)* ***Description:*** *Formerly Cyber Warfare Control System (CWCS) The Cyber Grand Challenge (CGC) program will create automated defenses that can identify and respond to cyber attacks more rapidly than human operators. CGC technology will monitor defended software and networks during operations, reason about flawed software, formulate effective defenses, and deploy defenses automatically. Technologies to be developed and integrated may include anomaly detection, Monte Carlo input generation, case-based reasoning, heuristics, game theory, and stochastic optimization. The CGC 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. DARPA will incentivize competition through a Grand Challenge in which CGC technologies compete head-to-head. ***FY 2014 Plans:*** - Develop instrumented competition framework for automated cyber defense. - Initiate development of automated cyber defenders to identify flaws and formulate defenses. - Conduct competitive assessments to identify the most promising technology solutions. ***FY 2015 Plans:*** - Extend development of automated cyber defenders to allow real time in situ network defense decision making. - Develop a cyber research corpus using techniques from game theory, other quantitative disciplines, and emergent behavior. - Conduct mid-term evaluation of cyber technologies through competitive challenges.	-	15.250	16.832
Accomplishments/Planned Programs Subtotals	33.745	67.849	67.349

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 2015 Defense Advanced Research Projects Agency												Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602304E / *COGNITIVE COMPUTING SYSTEMS*							
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
Total Program Element	-	27.538	16.330	-	-	-	-	-	-	-	-	-
COG-02: *COGNITIVE COMPUTING*	-	6.886	3.503	-	-	-	-	-	-	-	-	-
COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	-	20.652	12.827	-	-	-	-	-	-	-	-	-

The FY 2015 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 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602304E / *COGNITIVE COMPUTING SYSTEMS*

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	30.424	16.330	-	-	-
Current President's Budget	27.538	16.330	-	-	-
Total Adjustments	-2.886	-	-	-	-
• Congressional General Reductions	-0.040	-			
• Congressional Directed Reductions	-2.573	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.510	-			
• SBIR/STTR Transfer	-0.783	-			

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004, sequestration adjustments, and the SBIR/STTR transfer offset by reprogrammings.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602304E / *COGNITIVE COMPUTING SYSTEMS*	Project (Number/Name) COG-02 / *COGNITIVE COMPUTING*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
COG-02: *COGNITIVE COMPUTING*	-	6.886	3.503	-	-	-	-	-	-	-	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: Autonomous Robotic Manipulation (ARM)	6.886	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 2013 Accomplishments:

- Developed and demonstrated algorithms for autonomous grasping of complex objects, such as the handle of an impact driver to change a tire or a cutting tool to snip a wire.
- Developed and demonstrated algorithms for autonomous bimanual manipulation, such as unzipping a satchel bag to open it and extracting an object.
- Developed a set of new, low-cost robotic manipulators that were used by various platforms to test the robustness of the designs.

FY 2014 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602304E / *COGNITIVE COMPUTING SYSTEMS*	**Project (Number/Name)** COG-02 / *COGNITIVE COMPUTING*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop and demonstrate 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	6.886	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 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602304E / *COGNITIVE COMPUTING SYSTEMS*	Project (Number/Name) COG-03 / *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
COG-03: *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*	-	20.652	12.827	-	-	-	-	-	-	-	-	-

The FY 2015 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.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Transformative Apps	20.652	12.827	-

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 2013 Accomplishments:
- Integrated and tested with military tactical radio networks.
- Demonstrated interoperability with Army systems on mounted platforms.
- Developed the apps certification process and deployed to Army users.
- Expanded apps library and initiated transition to program of record.

FY 2014 Plans:
- Demonstrate full interoperability across hybrid network topologies in a range of operationally relevant contexts.
- Refine decentralized imagery processing and dissemination methods for below-brigade users.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602304E / *COGNITIVE COMPUTING SYSTEMS*	**Project (Number/Name)** COG-03 / *COLLECTIVE COGNITIVE SYSTEMS AND INTERFACES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Investigate enhanced counter-IED and situational awareness apps for training and CONUS exercises.			
Accomplishments/Planned Programs Subtotals	20.652	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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602383E / *BIOLOGICAL WARFARE DEFENSE*

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	-	15.131	24.537	44.825	-	44.825	52.560	55.647	53.623	60.747	-	-
BW-01: *BIOLOGICAL WARFARE DEFENSE*	-	15.131	24.537	44.825	-	44.825	52.560	55.647	53.623	60.747	-	-

The FY 2015 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 the detection, prevention, treatment and remediation of biological, chemical, and radionuclide threats.

Efforts to counter existing and emerging biological, chemical and radiological threats include countermeasures to stop the pathophysiologic processes that occur as a consequence of an attack, host immune response enhancers, medical diagnostics for the most virulent pathogens and their molecular mechanisms, collection of environmental trace constituents to support chemical mapping, tactical and strategic biological, chemical, and radiological sensors, and integrated defense 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 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	19.236	24.537	28.825	-	28.825
Current President's Budget	15.131	24.537	44.825	-	44.825
Total Adjustments	-4.105	-	16.000	-	16.000
• Congressional General Reductions	-0.025	-			
• Congressional Directed Reductions	-1.300	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.275	-			
• SBIR/STTR Transfer	-0.505	-			
• TotalOtherAdjustments	-	-	16.000	-	16.000

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004, sequestration adjustments, reprogrammings, and the SBIR/STTR transfer.
FY 2015: Increase reflects new emphasis placed on chemical and nuclear threat defense.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602383E / *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Medical Countermeasures	15.131	24.537	26.825

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 chemical and radiological 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 2013 Accomplishments:
- Assembled two or more IVTCs to recapitulate the function of intact human physiological systems.
- Demonstrated a modular platform able to sustain the integrated IVTCs for 1 week.
- Demonstrated that integrated IVTCs respond and react to test compounds in a manner that corresponds to the known effects of those compounds on human physiological systems.
- Demonstrated an automated prototype system for the construction and maturation of IVTCs.

FY 2014 Plans:
- Demonstrate that the modular platform can be used to predict the kinetics of metabolism and elimination that test compounds are known to exhibit in 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.
- Investigate novel radiation dosimeter approach to mitigate exposure.

FY 2015 Plans:
- Demonstrate an expanded set of IVTCs able to reproduce the function of four human physiological systems.
- Demonstrate an automated prototype system for monitoring the health and response of IVTCs to test compounds.
- Design and build additional modules that are compatible with the expanded set of IVTCs and enable the platform to sustain the integrated IVTCs for 3 weeks.
- Demonstrate that the expanded set of four IVTCs individually respond and react to test compounds in a manner consistent with the known effects of those compounds on the corresponding human tissues.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602383E / *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate that a modular arrangement of the expanded set of four IVTCs can be used to predict the absorption, distribution, metabolism and elimination that the test compounds are known to exhibit in human physiological systems. - Develop models for understanding, predicting, and reducing the epigenetic impacts following exposure to ionizing radiation.			
Title: Unconventional Approaches to Chemical Weapons Defense (CWD) ***Description:*** The Unconventional Approaches to CWD program will develop and demonstrate approaches to inactivate hazardous chemical agents for a number of DoD applications including personnel protection, therapeutics, and bulk demilitarization of chemical weapons caches. Existing approaches to deactivating warfare agents are difficult to implement in non- and semi-permissive environments or are too slow/expensive to achieve over large permissive environments. These limitations coupled with the emergence of new, low cost technologies for producing chemical weapons drive a need for countermeasures that are simple and fast to implement and improve U.S. strategic response to emerging chemical threats. Approaches to be considered under the Unconventional Approaches to CWD program include creation of catalysts to accelerate the hydrolysis of chemical agents, development of approaches utilizing smart-chemistry to achieve stand-off demilitarization, construction of a small rapid remediation approach for use in semi-permissive environments, and identification of drugs or antidotes designed to protect those demilitarizing chemical agents in semi-permissive environments. ***FY 2015 Plans:*** - Demonstrate increased decomposition rate of chemical agents using novel catalysts. - Demonstrate continuous method for demilitarization of chemical agents using non-potable water. - Identify novel strategies particularly those intrinsic to the human body to enhance warfighter protection against chemical agents.	-	-	7.100
Title: Defense Against Mass Terror Threats ***Description:*** The objective of the Defense Against Mass Terror Threats program is to identify and develop technologies that have the potential to significantly improve U.S. ability to reduce the risk of mass casualties in the wake of a nuclear attack. Challenges in reducing U.S. vulnerability to a nuclear attack include monitoring radiation levels and exposure in urban areas and mitigating the lethal short and long term effects of ionizing radiation. One goal of this program is to develop new sensors and sensing networks that can economically and reliably provide wide area monitoring of radionuclide signatures. Another goal is to investigate new therapies and decontamination strategies that can mitigate both the long- and short-term biophysical health impacts of exposure to ionizing radiation. ***FY 2015 Plans:*** - Investigate novel therapies for repairing cellular damage and mutagenesis associated with long term susceptibility to various cancers from exposure to ionizing radiation. - Develop the requirements for a low cost, pervasive detection network for wide area monitoring of radionuclide exposure.	-	-	10.900

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602383E / *BIOLOGICAL WARFARE DEFENSE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate novel manufacturing approaches that can lower the cost of radiation detectors without compromising performance.			
Accomplishments/Planned Programs Subtotals	15.131	24.537	44.825

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 2015 Defense Advanced Research Projects Agency											Date: March 2014	
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*							
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
Total Program Element	-	209.578	218.209	305.484	-	305.484	340.564	339.388	344.594	356.710	-	-
TT-03: *NAVAL WARFARE TECHNOLOGY*	-	46.342	32.744	33.829	-	33.829	50.732	60.839	59.975	54.522	-	-
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	-	30.883	57.792	70.855	-	70.855	69.355	48.855	60.355	65.185	-	-
TT-06: *ADVANCED TACTICAL TECHNOLOGY*	-	19.336	16.045	23.329	-	23.329	36.773	52.542	53.603	64.443	-	-
TT-07: *AERONAUTICS TECHNOLOGY*	-	40.509	31.026	61.126	-	61.126	54.371	61.942	56.361	63.245	-	-
TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*	-	72.508	80.602	116.345	-	116.345	129.333	115.210	114.300	109.315	-	-

The FY 2015 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 Technology.

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.

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

The Advanced Tactical Technology project focuses on broad technology areas including: a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, holographic laser sensors, communications, and high-power laser applications; and b) new tactical systems for enhanced air vehicle survivability, precision optics, electronic warfare, and advanced air breathing weapons.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*

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.

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. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	233.209	225.977	236.874	-	236.874
Current President's Budget	209.578	218.209	305.484	-	305.484
Total Adjustments	-23.631	-7.768	68.610	-	68.610
• Congressional General Reductions	-0.301	-			
• Congressional Directed Reductions	-19.883	-10.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	2.232			
• Congressional Directed Transfers	-	-			
• Reprogrammings	2.554	-			
• SBIR/STTR Transfer	-6.001	-			
• TotalOtherAdjustments	-	-	68.610	-	68.610

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004 and directed reductions, sequestration adjustments, and the SBIR/STTR transfer offset by reprogrammings.

FY 2014: Decrease reflects a program cancellation offset by a program increase.

FY 2015: Increase reflects additional emphasis placed on Network Defense, Big Data, Land System Technologies, and Aeronautics programs.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*	Project (Number/Name) TT-03 / *NAVAL WARFARE TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
TT-03: *NAVAL WARFARE TECHNOLOGY*	-	46.342	32.744	33.829	-	33.829	50.732	60.839	59.975	54.522	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: Anti-Submarine Warfare (ASW) Continuous Trail Unmanned Vessel (ACTUV)	37.400	20.831	11.865

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 2013 Accomplishments:
- Completed ACTUV detailed design and conducted critical design review.
- Performed demonstrations of ACTUV critical enabling technologies.
- Conducted integrated system demonstration on ACTUV surrogate hardware-in-the-loop system.

FY 2014 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-03 / *NAVAL WARFARE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete ACTUV sensor testing on surrogate platform. - Initiate ACTUV prototype vessel construction. - Integrate software and hardware into the ACTUV platform. ***FY 2015 Plans:*** - Complete construction of prototype vessel. - Conduct at-sea testing to validate performance of vessel, sensor systems, and autonomy.			
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. Building upon and complimenting concepts for maritime situational awareness and ISR developed under the DASH program, budgeted in Project PE 0603766E/NET-02, 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 analysis to characterize long-range deep sea communications. - Develop conceptual designs for deep sea containment and launch. ***FY 2015 Plans:*** - Develop a payload capable of achieving its effect or sensing range required to scale for the program's coverage area. - Develop a riser to hold the payload at pressure, and launching it to the surface from an intermediate ocean depth. - Demonstrate an integrated riser and payload using surrogate communications to initiate deployment to the surface. - Initiate development of communications subsystems.	-	11.913	18.964
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	5.942	-	3.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-03 / *NAVAL WARFARE TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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 and domain awareness. ***FY 2013 Accomplishments:*** - Initiated system studies and subsystem technology assessments for novel under-ice and near-ice surveillance. - Conducted technology assessments and performed technology demonstrations in climactic laboratories. - Conducted Arctic data collections analyses. - Completed initial Arctic surveillance system studies. - Developed canonical datasets including environmental data collections to support future design studies and technology efforts. ***FY 2015 Plans:*** - Recover data collection systems and commence data analysis. - Participate in Navy Ice Experiment (ICEX). - Complete data collection analysis.			
Title: Tactically Expandable Maritime Platform (TEMP) ***Description:*** The Tactically Expandable Maritime Platform (TEMP) program sought to develop and demonstrate macroscopic integrated systems built up from International Organization for Standardization (ISO) modular technologies that could be operated from unmodified commercial container ships and deliver credible naval capability for high priority missions. TEMP developed enabling modular technologies and evaluated the feasible range of naval missions that could be serviced from this highly flexible and cost effective unconventional force structure model. TEMP also evaluated a Humanitarian Assistance and Disaster Relief (HA/DR) mission, engineering a modular first responder capability to allow rapid force closure capability following a disaster event. ***FY 2013 Accomplishments:*** - Conducted TEMP Modular Sea Depot ballast testing and prototype operational demonstration. - Conducted incremental risk reduction testing of TEMP critical enabling technologies, including modularized air delivery vehicle and modularized sea delivery vehicle.	3.000	-	-
Accomplishments/Planned Programs Subtotals	46.342	32.744	33.829

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-03 / *NAVAL WARFARE TECHNOLOGY*

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 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*	Project (Number/Name) TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
TT-04: *ADVANCED LAND SYSTEMS TECHNOLOGY*	-	30.883	57.792	70.855	-	70.855	69.355	48.855	60.355	65.185	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: Fast, Adaptable, Next Generation Ground Combat Vehicle (FANG)	11.919	7.000	-

Description: The goals of the Fast, Adaptable, Next-Generation Ground Combat Vehicle (FANG) program are to employ a novel, model-based design and verification capability, a highly-adaptable foundry-style manufacturing capability, and collaborative 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 events, leading to the building of designs in a foundry-style, rapidly configurable manufacturing facility.

FY 2013 Accomplishments:
- Performed experimental subsystem designs using the vehicle design environment as well as the iFAB Foundry.
- Promulgated component model libraries, foundry capabilities, and objective design criteria for the first FANG Challenge covering an Infantry Fighting Vehicle (IFV) drivetrain and mobility subsystem.
- Maintained and developed incremental upgrades to the collaborative vehicle design environment.
- Conducted the first FANG Challenge, a competitive, collaborative design contest for the drivetrain and mobility subsystem of a heavy, amphibious IFV.

FY 2014 Plans:
- 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.
- Conduct AVM tool suite validation testing, a rigorous test of META and iFAB capabilities executed by relevant industry teams and focused on the chassis and survivability subsystem of a heavy, amphibious IFV.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Transition component model standards, tool integration standards, and VehicleFORGE software tool suite and associated technology to the Digital Manufacturing and Design Innovation Institute (DMDII) through the use of co-funded research and formal technology transition activities for industry use.			
Title: Ground Experimental Vehicle (GXV) ***Description:*** The goal of the Ground Experimental Vehicle (GXV) program, leveraging architectures from the META program (funded in PE 0602303E, Project IT-02), is to achieve significant improvements in military ground vehicle performance, fundamentally enabled through achievement of crew/vehicle survivability through means alternative to the traditional mass-based armor solutions. This will be accomplished through development of core ground combat and tactical vehicle technologies related to platform mobility, survivability through agility, improved signature management, semi-automated crew functions, and improved overall platform/unit tactical utility. The GXV program will develop technologies at the subsystem to integrated platform level, along with performance demonstrated through fully capable concept vehicles. A key program thread is pursuing platform technologies that allow extreme reductions in integrated system volume, weight, and crew while conserving crew survivability, improving deployability, and increasing force effectiveness. The GXV program will support a systems engineering-based GXV architecture that enhances technology development at the component and subsystem level. Modeling and simulation for technical analysis and evaluation, as well as operational assessments, will be included in the GXV effort. ***FY 2014 Plans:*** - Initiate development in GXV technology areas. - Develop technical requirements and operational strategies for vehicles with Service user communities. ***FY 2015 Plans:*** - Complete definition of initial systems architectures. - Conduct preliminary design review of technology development efforts. - Finalize overall concept platform requirements.	-	10.000	18.000
Title: Robotics Challenge ***Description:*** The Robotics Challenge program 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. Anticipated Service users include the Army, Marines, and Special Forces.	18.964	19.560	9.855

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Designed robot systems and developed algorithms for locomotion and controls. - Conducted the Virtual Robotics Challenge. - Defined 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. ***FY 2015 Plans:*** - Conduct the DARPA Robotics Challenge Finals. - Perform analysis and report findings to document advancements achieved as a result of the challenge.			
Title: Infantry Squad Systems (IS2) ***Description:*** The U.S. military achieves overmatch against its adversaries via vehicles in all regimes - land, sea and air; however, this level of overmatch is not enjoyed at the squad to individual dismounted warfighter level. 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 with substantial combat overmatch. 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. The end result of the IS2 program is an individual dismount unit 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:*** - Perform CONOPS and systems architecture trade 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. - Implement a testbed that leverages breakthroughs from existing program efforts to allow assessments of new technologies. - Initiate technology development efforts in the areas of situational awareness, command & control and squad effects. - Exercise developed technology via the IS2 testbed and simulation environments. ***FY 2015 Plans:***	-	12.000	20.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-04 / *ADVANCED LAND SYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Refine technology development efforts, focusing on enhanced sensor capabilities, full immersion soldier display units, and content distribution. - Leverage IS2 testbed and simulation environments to iteratively refine developed technology and architecture scheme. - Initiate a full system integration effort utilizing most promising technologies from the IS2 testbed and simulation evaluations with the goal of live experimentation.			
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 maneuvering lower tier naval threats. ***FY 2014 Plans:*** - Conduct systems architecture trades and cost studies. - Initiate design studies of candidate weapons systems. ***FY 2015 Plans:*** - Initiate technology development efforts focusing on guidance, packaging and delivery method. - Initiate test cycle to refine system metrics tied to reliability and precision. - Engage involvement from potential transition partners early in process to ensure feedback is integrated into system design. - Begin examining candidate platforms for out-year live-fire tests.	-	9.232	15.000
Title: Robotics Fast Track ***Description:*** To be dominant in robotics of the future, the DoD will need to embrace programs designed to create disruptive advances in robotics capabilities that are measured in months rather than years, and whose individual costs may largely be measured in thousands of dollars rather than millions. The Robotics Fast Track program seeks to revolutionize robotics technologies by promoting non-traditional technical opportunities. The program will create low-cost, high-utility robotic component solutions by engaging a novel performer community in research efforts that result in prototype systems and proofs of concept in months, at a fraction of the cost of traditional design processes. The Robotics Fast Track program will engage numerous robotics related efforts across the spectrum of robotics professionals and enthusiasts, extending the existing performer base to include non-standard, cutting edge organizations and individuals throughout the robotics community. The program will demonstrate the ability for robotics projects to be performed at an asymmetric advantage in time, cost, and contribution of the efforts in comparison	-	-	8.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
to more traditional applied research areas. This will apply to both performance of individual efforts and to the contracting required to engage performers in said efforts. ***FY 2015 Plans:*** - Begin outreach with nontraditional performer community. - Baseline fundamental robotic system and subsystem needs. - Begin execution of multiple performance developments - Initial release of robotics fast track catalog.			
Accomplishments/Planned Programs Subtotals	30.883	57.792	70.855

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 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*	Project (Number/Name) TT-06 / *ADVANCED TACTICAL TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
TT-06: *ADVANCED TACTICAL TECHNOLOGY*	-	19.336	16.045	23.329	-	23.329	36.773	52.542	53.603	64.443	-	-

The FY 2015 OCO Request will be submitted at a later date.

A. Mission Description and Budget Item Justification

This project focuses on broad technology areas including: a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, holographic laser sensors, communications, and high-power laser applications; and b) new tactical systems for enhanced air vehicle survivability, precision optics, electronic warfare, and advanced air breathing weapons.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Endurance	15.336	11.545	13.129

Description: The Endurance program will develop technology for pod-mounted lasers to protect a variety of airborne platforms from emerging and legacy electro-optical/infrared (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 leveraging technology developed in the Excalibur program and conducting applied research in support of the 6.3 funded Endurance program budgeted in PE 0603739E, Project MT-15.

FY 2013 Accomplishments:
- Developed preliminary designs for an objective brassboard system.
- Completed critical designs of subsystems: size, weight and required power of brassboard laser weapon system estimated.
- Built detailed sub-system models and identified risk elements, determined parameters for system success under operational stressors.

FY 2014 Plans:
- Identify the physical interactions impacting testing and their expected effect on the capture of testing metrics.
- Continue design for the objective brassboard system within form, fit, function, and operational parameters of an objective flight-prototype.
- Develop plans for laser effects testing including the identification of suitable test articles.

FY 2015 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-06 / *ADVANCED TACTICAL TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete design of the objective brassboard within form, fit, function, and operational parameters of an objective flight prototype.			
Title: International Space Station SPHERES Integrated Research Experiments (InSPIRE) ***Description:*** 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. InSPIRE will enhance the ability to rapidly mature and insert new technologies into national security space assets. The InSPIRE program expands on the capabilities matured through SPHERES by developing, building and launching new hardware and software elements that expand the baseline capabilities. These capabilities enable use of SPHERES as a testbed for more complex experimentation, providing affordable opportunities to test new space technologies. ***FY 2013 Accomplishments:*** - Conducted second Zero Robotics competition. - Launched electromagnetic formation flight hardware to the ISS and began testing. - Upgraded online SPHERES simulation to incorporate addition of vision-based navigation hardware. - Designed and prototyped docking port for SPHERES. ***FY 2014 Plans:*** - Build and launch docking ports for SPHERES to enhance rendezvous and docking test capabilities. - Build and launch structures for SPHERES that expand upon its ability to integrate with additional hardware. - Conduct testing of tele-operations capabilities on the SPHERES devices on ISS, from the ground. - Develop and execute additional rendezvous and proximity operations experiments using SPHERES inside ISS. ***FY 2015 Plans:*** - Conduct on-orbit testing of new SPHERES docking ports and structures.	4.000	4.500	3.200
Title: LUSTER (Laser Ultraviolet Sources for Tactical Efficient Raman) ***Description:*** The Laser UV Sources for Tactical Efficient Raman (LUSTER) program is developing a compact semiconductor laser that emits in the deep UV (i.e. wavelength <250 nanometers) and is capable of an output power of 1 Watt with high efficiency and spectral purity suitable for a wide array of spectroscopy applications. Such an achievement will represent a significant advance over the state of the art, as existing lasers in this wavelength range are bulky, highly inefficient, and expensive, as there are no available semiconductor lasers that can emit in the UV range <250nm. LUSTER will leverage lessons learned in growing high quality light emitting material from the Compact Mid-Ultraviolet Technology (CMUVT) program. The compact size of	-	-	7.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
semiconductor lasers along with the LUSTER performance goals will enable many applications including but not limited to standoff Raman spectroscopy which is of interest for DoD applications such as chemical agent sensing. ***FY 2015 Plans:*** - Evaluate the design and growth of laser epitaxial material, focusing on low-defect growth, optimal electrical and optical confinement and methods for high efficiency and power operation. - Evaluate development of laser pumping technologies, such as the use of compact electron-beam sources. - Evaluate methods for using non-linear crystals to efficiently convert longer wavelength lasers in the 500 nanometer range down to the 250 nanometer range.			
Accomplishments/Planned Programs Subtotals	19.336	16.045	23.329

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 2015 Defense Advanced Research Projects Agency									Date: March 2014			
Appropriation/Budget Activity 0400 / 2					R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*				Project (Number/Name) TT-07 / *AERONAUTICS TECHNOLOGY*			
COST ($ in Millions)	**Prior Years**	**FY 2013**	**FY 2014**	**FY 2015 Base**	**FY 2015 OCO #**	**FY 2015 Total**	**FY 2016**	**FY 2017**	**FY 2018**	**FY 2019**	**Cost To Complete**	**Total Cost**
TT-07: *AERONAUTICS TECHNOLOGY*	-	40.509	31.026	61.126	-	61.126	54.371	61.942	56.361	63.245	-	-

The FY 2015 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)	FY 2013	FY 2014	FY 2015
Title: Vertical Take-Off and Landing (VTOL) Technology Demonstrator	8.908	21.026	36.126

Description: The Vertical Take-Off and Landing (VTOL) Technology Demonstrator program will demonstrate revolutionary improvements in (heavier than air) VTOL air vehicle capabilities and efficiencies through the development of subsystem and component technologies, aircraft configurations and system integration. The program will build and flight test a manned or unmanned 10,000 - 12,000 lb aircraft capable of sustained speeds in excess of 300 kt, demonstrate system level hover efficiency within 25% of the ideal, and a lift-to-drag ratio no less than ten. Additionally, the demonstrator will be designed to have a useful load of no less than 40% of the gross weight. A strong emphasis will be placed on the development of elegant, multi-functional subsystem technologies that demonstrate net improvements in aircraft efficiencies to enable new and vastly improved operational capabilities.

FY 2013 Accomplishments:
- Performed complex simulations to baseline expected aircraft performance, validated system concepts and established development plans for underlying technologies.
- Defined and initiated design iterations, propulsion system requirements, trade studies, and technology evaluation approaches.
- Defined flight test objectives, test approach and test verification and validation requirements and approach.
- Defined software and hardware integration approach and baseline controls necessary for successful air vehicle concept.

FY 2014 Plans:
- Define key technologies and verify performance capabilities.
- Understand and evaluate technical and programmatic risk elements, define mitigation plans and analyses of alternatives.
- Complete conceptual design of configurations and all subsystems.
- Initiate preliminary design of configuration and all subsystems.
- Hold system definition reviews to evaluate subsystem integration into air vehicle design and technology development paths to meet program objectives.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602702E / *TACTICAL TECHNOLOGY*	**Project (Number/Name)** TT-07 / *AERONAUTICS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Perform simulations to establish expected system level performance and validate the system concept and underlying enabling technologies. - Define software and hardware integration approach and baseline controls necessary for successful air vehicle concept. - Perform trade studies to refine configuration and subsystem designs. - Evaluate performance capabilities, and conduct objective aircraft operational analyses. - Refine and consolidate flight test and validation approaches, flight test missions, and test range requirements. ***FY 2015 Plans:*** - Perform subscale wind tunnel and laboratory testing for aerodynamic data base and flight controls development. - Refine power generation and distribution/integration concepts. - Perform propulsion and power system scaled model bench testing. - Design and develop subscale flight models for configuration viability and control law validation. - Validate computational performance predictions against empirical data. - Refine full scale engine integration design. - Continue preliminary design refinements leading toward detailed design of the demonstrator aircraft and associated subsystems. - Create detailed system integration plans. - Prepare detailed airworthiness and flight test preparation requirements in support of flight test schedule. - Complete preliminary design of all subsystems.			
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 2013 Accomplishments:*** - Continued to perform evaluation studies of emergent technologies. - Conducted performance trade analyses for a tactical strike weapon concept. - Conducted testing of enabling technology components. ***FY 2014 Plans:*** - Perform testing of enabling technology components. - Initiate conceptual system designs.	5.000	2.000	2.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop technology maturation plan and risk reduction strategy. ***FY 2015 Plans:*** - Initiate new studies of novel technologies. - Conduct risk reduction tests of candidate technologies.			
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 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. ***FY 2015 Plans:*** - Investigate component technologies with potential to enable specific concepts, including advanced propulsion and materials. - Explore innovative approaches for significantly increasing lift to drag ratio. - Evaluate approaches to rapidly deliver cargo and equipment directly from offshore to the battlefield without infrastructure.	-	3.000	4.000
Title: Aircrew Labor In-cockpit Automation System (ALIAS)* ***Description:*** *Formerly Adaptive Integrated Reliability The Aircrew Labor In-cockpit Automation System (ALIAS) program, previously funded in PE 0602303E, Project IT-02, will design, develop, and demonstrate a kit enabling affordable, rapid automation of selected aircrew functions across a broad range of aircraft. ALIAS intends to enable reduction of aircrew workload and/or the number of onboard aircrew, to improve performance. The program will develop hardware and software to automate select aircrew functions and will employ novel, low impact approaches to interfacing with existing aircraft monitoring and control systems. The program will also develop tractable approaches to rapidly capture crew-station specific skills and aircraft unique behaviors. To accomplish this, ALIAS will leverage recent advances in perception, manipulation, machine learning, reusable software architectures, autonomous systems	-	5.000	14.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
architecture, and verification and validation. ALIAS will culminate in a demonstration of the ability to rapidly adapt a single system to two aircraft and execute simple missions. This reliability enhancement capability will enable new operational concepts for reuse of existing air assets and allow a reduction in the number of aircrew required. ***FY 2014 Plans:*** - Execute a ground-based proof of concept study refining an approach to crew station interfacing. - Initiate development of core crew station technologies. - Initiate development of adaptable learning approaches. ***FY 2015 Plans:*** - Design and commence prototyping of an initial ground-based ALIAS system. - Initiate simulator-based demonstration of complete automation system including training and adaptation of system to multiple crew member roles. - Initiate planning for flight demonstration of system adaptation and mission execution.			
Title: Swarm Challenge ***Description:*** The goal of the Swarm Challenge is to develop autonomous swarming algorithms for Unmanned Vehicle (UxVs) to augment ground troops performing missions in a complex environment, without creating a significant cognitive burden. The program will evaluate the effectiveness of swarming for UxVs supporting ground operations, air operations, maritime operations, undersea operations, or search and rescue operations. Challenges include the ability for the UxV to collaborate to rapidly survey an area leveraging other UxVs to solve problems related to, for example, perception, decision making, or obstacle clearing. The challenge emphasizes minimum operator training and supervision so that the operator can continue to perform his/her normal duties while using UxVs as force multipliers. ***FY 2015 Plans:*** - Perform trade studies for system approach, functional and cognitive decomposition. - Select architecture for software, communication, computation, perception, and simulation environment. - Procure hardware and modify to enable demonstration of autonomy algorithms. - Develop autonomous algorithms and associated software. - Initiate first round of evaluation in simulated environment and then in physical environment.	-	-	5.000
Title: Mission Adaptive Rotor (MAR) ***Description:*** The Mission Adaptive Rotor (MAR) program sought 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. The MAR program designed, tested, and matured active rotor technologies,	5.641	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
facilitating 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. ***FY 2013 Accomplishments:*** - Completed fabrication design of retreating side blowing concepts for full-scale rotor blades to improve high speed flight capabilities and maneuver margins, initially applicable to utility class helicopters, but relevant to all edgewise flight rotorcraft. - Completed design of high solidity, co-rotating proprotor for tilt rotor applications to enable improved high altitude flight and reduced power consumption. - Conducted analyses, simulations and subscale wind tunnel and ground-based testing of key rotor technologies to meet MAR objectives. - Designed, simulated and performed micro scale ground tests of robotic landing gear for rotorcraft to enable uneven terrain and enhanced ship based operations. - Performed analysis and simulations of advanced VTOL configurations including fan-in-wing for sizing studies and military utility analysis. - Performed analyses and wind tunnel testing of a fan-in-wing concept to understand the flow field and possibilities of using the fan as an aerodynamic fairing. - Completed proprotor hover test and data analysis. - Completed robotic landing gear technology suite and scaled demonstration on flight test model rotorcraft.			
Title: Aerial Reconfigurable Embedded System (ARES)*	20.960	-	-
Description: *Formerly Transformer (TX) Vehicle Current and future land and ship-to-shore operations will require rapid and distributed employment of U.S. forces on the battlefield. The Aerial Reconfigurable Embedded System (ARES) program will develop a vertical take-off and landing (VTOL), modular unmanned air vehicle that can carry a 3,000 lb useful load at a range of 250 nautical miles on a single tank of fuel. ARES will enable distributed operations and access to compact, high altitude landing zones to reduce warfighter exposure to hostile threats and bypass ground obstructions. ARES modular capability allows for different mission modules to be quickly deployed at the company level. This enables the flexible employment of the following capabilities: cargo resupply, casualty evacuation, reconnaissance, weapons platforms, and other types of operations. The enabling technologies of interest include adaptive wing structures, ducted fan propulsion system, lightweight materials, and advanced flight controls for stable transition from vertical to horizontal flight. Additionally, the program will explore new adaptable landing gear concepts to enable operations from irregular landing zones and moving launch/recovery platforms. ARES vehicles could be dispatched for downed airman recovery, for evacuating injured personnel from difficult-to-access locations, or to resupply isolated small units. ARES is well suited for enhanced company operations concepts which would provide the warfighter/team increased situational awareness for operations in an urban environment. Beginning in FY14, this program will be funded from PE 0603286E, Project AIR-01.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Finalized analysis, trade studies, and prototype vehicle element designs to meet the program measures of performance. - Conducted powered wind tunnel testing to increase the fidelity of flight control system development and verified vehicle performance simulations, showing feasibility and function of the design. - Conducted key component tests demonstrating feasibility and function. - Conducted component hardware-in-the-loop testing to ensure successful integration of prototype vehicle subsystems. - Prepared draft test plans for ground and flight test demonstration.			
Accomplishments/Planned Programs Subtotals	40.509	31.026	61.126

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 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	R-1 Program Element (Number/Name) PE 0602702E / *TACTICAL TECHNOLOGY*	Project (Number/Name) TT-13 / *NETWORK CENTRIC ENABLING TECHNOLOGY*	

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
TT-13: *NETWORK CENTRIC ENABLING TECHNOLOGY*	-	72.508	80.602	116.345	-	116.345	129.333	115.210	114.300	109.315	-	-

The FY 2015 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 2013	FY 2014	FY 2015
Title: XDATA	15.275	25.800	38.817

Description: 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, metadata, 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 Accomplishments:
- Explored scalable methods for processing vast amounts of incomplete and imperfect data.
- Developed a baseline of open source analytics and visualization technologies for large data processing.
- Initiated development of a framework for workflow characterization and rapid composition of large data processing systems with advanced analytics and visualization for diverse missions and platforms.
- Demonstrated proof-of-concept system on sample open source data.
- Engaged DoD and other government stakeholders for feedback on proof-of-concept prototypes.

FY 2014 Plans:

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop a framework for processing data from diverse sources with advanced analytics and visualization for diverse missions and platforms. - Develop and demonstrate analytic tools for temporal and pattern analysis on petabyte scale. - Initiate methods for uncertainty representation, processing, propagation, and visualization. - Develop methods for dimensionality reduction for faster approximate processing with characterized accuracy. - Develop adaptive visualization methods for large data for varying users and contexts. - Develop an integrated framework for rapidly implementing analytics on a given computational platform with the ability to systematically trade off processing time and accuracy. - Demonstrate end-to-end systems in transactional problem domains from multiple defense mission areas. ***FY 2015 Plans:*** - Develop methods for interactive, iterative, and distributed analysis of diverse data at exabyte scale. - Optimize analytic methods and software for implementation on heterogeneous platforms and operating environments. - Optimize visualization technology to rapidly adapt to a new mission and context. - Demonstrate the initial implementation of a rich library of software tools for rapid use in mission and user specific contexts. - Demonstrate end-to-end systems on data and problems of end users from DoD (Army, SOCOM, Air Force, and Navy), intelligence, and law enforcement communities.			
Title: Visual Media Reasoning (VMR) ***Description:*** 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 and alerting the analyst to scenes that warrant the analyst's expert attention. ***FY 2013 Accomplishments:*** - Demonstrated a cloud-based reasoning engine which fuses the outputs of over 35 disparate computer vision algorithms to improve the quality of image query results. - Refined the user interface as well as the accuracy and performance of the system based on warfighter/analyst user group input. - Developed an image database indexing scheme that enables the fast, efficient search of a dataset of approximately one million images.	15.482	15.000	8.304

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Delivered a VMR experimental prototype that allows users to query by example and returns clusters of similar images for evaluation by the FBI. ***FY 2014 Plans:*** - Optimize the core reasoning engine to make reliable inferences across the Who, What, Where and When domains to produce more accurate answers to warfighter and intelligence analyst queries. - Refine query by example to achieve levels of accuracy, precision, and reliability that satisfy potential transition partner needs. - Extend indexing to video clips. - Enhance detection of the geo-physical content of images: water, desert, urban, interior, etc. - Implement preprocessing of poor-quality images (e.g., motion blur, contrast, intensity) to improve query results. - Deliver an experimental prototype for evaluation by the National Media Exploitation Center (NMEC) as a potential transition partner. ***FY 2015 Plans:*** - Configure the reasoning engine so the user can customize selected reasoning assumptions, such as typical vehicle size, to enhance query results for specific applications. - Include mechanisms for technical users to add new computer vision algorithms to the system. - Provide a quantified level of performance to show the advantage of multi-algorithm reasoning versus a single-algorithm approach. - Deliver robust full-featured prototypes to NMEC and the FBI as transition products. - Make selected enabling components of the system available to the public research community.			
Title: Network Defense ***Description:*** The Network Defense program will develop technologies to detect network attacks using network summary data. U.S. computer networks are continually under attack, and these attacks are typically handled by individual organizations as they occur. Analyzing network summary data across a wide array of networks will make it possible to identify trends and patterns visible only when the data is viewed as a whole and to detect recurring threats, patterns of activity, and persistent vulnerabilities. Network Defense will develop novel algorithms and analysis tools that enable a big picture approach for identifying illicit behavior in networks. This analysis and subsequent feedback to system administrators, security engineers, and decision makers will enhance information security in both the government and commercial sectors. The Network Defense program expands on research originally programmed under the Nexus 7 program in this Project. ***FY 2014 Plans:*** - Develop analytics that detect structured network attacks within a single network. - Develop tailored algorithms to detect recurring threats on a single network.	-	15.000	28.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Create a corpus of realistic benign and threat network data for test and evaluation of candidate techniques. ***FY 2015 Plans:*** - Enhance network analytics to detect structured attacks across multiple networks. - Create general purpose algorithms for detecting novel classes of attacks across multiple networks. - Develop methods for identifying persistent vulnerabilities within a network and across multiple networks. - Evaluate and optimize techniques on realistic network data.			
Title: Distributed Battle Management*	-	5.000	12.024
Description: *Formerly Manned-Unmanned Collaborative Autonomy The Distributed Battle Management program will develop mission-driven architectures, protocols, and algorithms for battle management in the contested environment. The military is turning to networked weapons and sensors on-board a heterogeneous mix of multi-purpose manned and unmanned systems. In contested environments, it is a challenge for command and control (C2) networks to communicate with subordinate platforms due to extensive adversarial cyber and electronic warfare operations, anti-satellite attacks, and the need for emissions control in the face of a formidable integrated air defense system. The Distributed Battle Management program will seek to develop a distributed command architecture with decentralized control of mission-focused asset teams. The architecture will enable rapid reaction to ephemeral engagement opportunities and maintain a reliable C2 structure, despite limited communications and platform attrition in continuously evolving threat environments. The program will incorporate highly automated decision making capability while maintaining vital human-on-the-loop operator approval. ***FY 2014 Plans:*** - Develop architecture and concept of operations (CONOPS) for teams of manned and unmanned platforms coordinating to accomplish a mission in a denied environment. - Develop a simulation environment in parallel with technology development. - Develop detailed requirements and initiate system engineering for a mission-focused team-level distributed battle management system intended to operate in the denied environment. - Explore and evaluate alternative architectures and cooperative control algorithms for team-level autonomy in a denied environment, as well as approaches for interacting with a human operator, and options for inserting software in operational platforms. ***FY 2015 Plans:*** - Develop detailed system architecture for the distributed battle management system. - Develop workflow and CONOPS for the human operator to interact with the battle management system. - Develop and prototype the protocols and algorithms for distributed battle management in a denied environment.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Stand-up modeling and simulation capability for test and performance evaluation and begin testing of prototype architecture and algorithms.			
Title: Quantitative Global Analytics ***Description:*** The Quantitative Global Analytics program will develop and integrate big data analysis technologies to enable commanders to detect dangerous trends and anticipate global events. In recent years we have seen how resource scarcity for necessities such as water and food can displace populations, destabilize nation-states, and precipitate global instability. Such ethnic, political, societal, economic, and environmental stresses can often be observed in advance through open source economic and financial indicators, as expressed in market activities. Market prices and volatility, which can be influenced by factors affecting production, transshipment, and/or delivery, may also provide signals in advance of disruptive events. Theoretically these signals can be a source of actionable information, but in practice it is difficult to generate useful intelligence due to the confounding effects of spurious signals and random noise. The Quantitative Global Analytics program will combine quantitative analysis of global and regional economic and financial data with natural language processing, social network analysis, computational social science, and climate studies to filter out such confounding effects to produce real-time intelligence from a wide variety of international open source data. The technologies developed in the Quantitative Global Analytics program will enhance situational awareness and generate indications and warning for new classes of cyber-social-economic-environmental threats. ***FY 2015 Plans:*** - Develop spatial stochastic models for cyber-social-economic-environmental data. - Incorporate computational social science, economic, and climate models in quantitative intelligence schemes based on market and financial data, social network data, and open source media. - Develop global and regional data sets for testing quantitative intelligence schemes for measuring trends/predicting events having a military or security dimension.	-	-	13.000
Title: Memex ***Description:*** The Memex program will develop the next generation of search technologies to revolutionize the discovery, organization, and presentation of domain-specific content. Current search technologies have limitations in search query format, retrieved content organization, and infrastructure support and the iterative search process they enable is time-consuming and inefficient, typically finding only a fraction of the available information. Memex will create a new domain-specific search paradigm to discover relevant content and organize it in ways that are more immediately useful to specific missions and tasks. In addition, Memex domain-specific search engines will extend the reach of current search capabilities to the deep web and non-traditional content. Memex technologies will enable the military, government, and commercial enterprises to find and organize mission-critical information on the Internet and in large intelligence repositories. Anticipated mission areas include counter-terrorism,	-	3.000	16.200

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
counter-drug, anti-money-laundering, and anti-human-trafficking, with transition partners from DoD and other U.S. government activities. The Memex program expands on research originally programmed under the Nexus 7 program in this project. ***FY 2014 Plans:*** - Conceptualize and design new search architectures to support domain-specific search in high priority mission areas. ***FY 2015 Plans:*** - Develop domain-specific search engines to automatically discover, access, retrieve/extract, parse, process, analyze, and manage web content in specified domains. - Implement the capability to index deep web and non-traditional structured and unstructured content that is dynamically-generated, unlinked, and in unconventional formats. - Develop information extraction techniques to categorize and classify discovered content based on mission/user task requirements.			
Title: Nexus 7 ***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 2013 Accomplishments:*** - Provided additional quick-response reach-back analytic capability to forward command echelons. - Extended algorithms, tools, and methodologies addressing new datasets and new formats applicable to other national security interests and provided analytical tool suites to users as requested. - Developed techniques for processing timely, relevant information from traditional and non-traditional data streams that may be incomplete and/or inaccurate.	26.975	16.802	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Transitioned enhanced algorithms, software, and analytical tool suites throughout DoD including the Army Tactical Cloud Integration Laboratory (TCIL) and SOCOM. - Recognized for providing a framework that provided unique and valuable insights against key strategic and operational questions in DARPA's receipt of the Joint Meritorious Unit Award for establishment of the DARPA Forward Cell. ***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. - Complete drawdown of forward deployed analytical cell in Afghanistan. - Transition suite of algorithms, software, and tools throughout DoD including DCGS-Army.			
Title: Extreme Accuracy Tasked Ordnance (EXACTO) ***Description:*** The Extreme Accuracy Tasked Ordnance (EXACTO) program demonstrated the ability to engage targets at extremely long ranges, regardless of target motion or crosswinds, with previously unachievable accuracy. The EXACTO system is comprised of an advanced targeting optic, the first ever guided, power-generating, small caliber bullet, innovative guidance and control (G&C) 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 reduced target engagement timelines. The technologies developed within the EXACTO program could also enable development of larger caliber guided lethality solutions, and enhanced Naval ship self-protection. ***FY 2013 Accomplishments:*** - Demonstrated in-flight maneuvers during live-fire testing. - Updated functionality of targeting optic. - Improved reliability of bullet aerodynamic performance. - Demonstrated accurate tracking and aimpoint maintenance on moving targets. - Improved system reliability and repeatability via live-fire testing. - Updated bullet hardware and G&C software to enable accurate bullet control.	10.000	-	-
Title: Mind's Eye ***Description:*** The Mind's Eye program developed a machine-based capability to learn generative representations of action among actors and objects in a scene, directly from visual inputs, and then to reason over those learned representations. Mind's Eye created the perceptual and cognitive underpinnings for reasoning about the action in scenes, enabling the generation of a	4.776	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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 Accomplishments:*** - Developed selected visual intelligence capabilities for human activity detection and integrated these into two prototype smart camera systems. - Developed visual analytics algorithms that detected different aspects of human activity and made the algorithms available for use by the wider computer vision community, including other government agencies, private industry, and academic researchers.			
Accomplishments/Planned Programs Subtotals	72.508	80.602	116.345

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.