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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Table of Volumes

Defense Advanced Research Projects Agency ..... **Volume 1**
Missile Defense Agency ..... **Volume 2**
Office of the Secretary of Defense ..... **Volume 3**
Chemical and Biological Defense Programs ..... **Volume 4**
Defense Contract Management Agency ..... **Volume 5**
Defense Human Resources Activity ..... **Volume 5**
Defense Information Systems Agency ..... **Volume 5**
Defense Logistics Agency ..... **Volume 5**
Defense Security Cooperation Agency ..... **Volume 5**
Defense Security Service ..... **Volume 5**
Defense Technical Information Center ..... **Volume 5**
Defense Threat Reduction Agency ..... **Volume 5**
The Joint Staff ..... **Volume 5**
U.S. Special Operations Command ..... **Volume 5**
Washington Headquarters Service ..... **Volume 5**
Operational Test and Evaluation ..... **Volume 5**

Defense Geospatial Intelligence Agency.....(see NIP and MIP Justification Books)

Defense Intelligence Agency.....(see NIP and MIP Justification Books)

National Security Agency.....(see NIP and MIP Justification Books)

Volume 1 Table of Contents

Comptroller Exhibit R-1 ..... **Volume 1 - v**

Program Element Table of Contents (by Budget Activity then Line Item Number) ..... **Volume 1 - xiii**

Program Element Table of Contents (Alphabetically by Program Element Title) ..... **Volume 1 - xv**

Exhibit R-2's ..... **Volume 1 - 1**

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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 & OCO)	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

R-1C1: FY 2015 President's Budget (Published Version), as of February 24, 2014 at 08:24:35

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

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
Total Research, Development, Test & Evaluation	2,580,687	2,778,656		2,778,656	2,914,770

Defense-Wide
FY 2015 President's Budget
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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
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

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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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Defense Advanced Research Projects Agency
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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	
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Advanced Technology Development				1,083,348	1,168,878		1,168,878	1,344,864	
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164	0605898E	Management HQ - R&D	06	64,248	71,659		71,659	71,362	U

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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 Defense Advanced Research Projects Agency				2,580,687	2,778,656		2,778,656	2,914,770	

R-1C1: FY 2015 President's Budget (Published Version), as of February 24, 2014 at 08:24:35

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

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

Line Item	Budget Activity	Program Element Number	Program Element Title	Page
2	01	0601101E	DEFENSE RESEARCH SCIENCES	Volume 1 - 1
4	01	0601117E	BASIC OPERATIONAL MEDICAL SCIENCE	Volume 1 - 45

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

Line Item	Budget Activity	Program Element Number	Program Element Title	Page
9	02	0602115E	BIOMEDICAL TECHNOLOGY	Volume 1 - 51
13	02	0602303E	INFORMATION & COMMUNICATIONS TECHNOLOGY	Volume 1 - 65
14	02	0602304E	COGNITIVE COMPUTING SYSTEMS	Volume 1 - 95
15	02	0602383E	BIOLOGICAL WARFARE DEFENSE	Volume 1 - 101
20	02	0602702E	TACTICAL TECHNOLOGY	Volume 1 - 105
21	02	0602715E	MATERIALS AND BIOLOGICAL TECHNOLOGY	Volume 1 - 133
22	02	0602716E	ELECTRONICS TECHNOLOGY	Volume 1 - 153

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

Line Item	Budget Activity	Program Element Number	Program Element Title	Page
40	03	0603286E	ADVANCED AEROSPACE SYSTEMS	Volume 1 - 179
41	03	0603287E	SPACE PROGRAMS AND TECHNOLOGY	Volume 1 - 191
59	03	0603739E	ADVANCED ELECTRONICS TECHNOLOGIES	Volume 1 - 203
60	03	0603760E	COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS	Volume 1 - 217
61	03	0603765E	CLASSIFIED DARPA PROGRAMS	Volume 1 - 239
62	03	0603766E	NETWORK-CENTRIC WARFARE TECHNOLOGY	Volume 1 - 241
63	03	0603767E	SENSOR TECHNOLOGY	Volume 1 - 257

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

Line Item	Budget Activity	Program Element Number	Program Element Title	Page
155	06	0605502E	SMALL BUSINESS INNOVATION RESEARCH	Volume 1 - 277
164	06	0605898E	MANAGEMENT HQ - R&D	Volume 1 - 279
171	06	0305103E	CYBER SECURITY INITIATIVE	Volume 1 - 281

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

Program Element Title	Program Element Number	Line Item	Budget Activity	Page
ADVANCED AEROSPACE SYSTEMS	0603286E	40	03	Volume 1 - 179
ADVANCED ELECTRONICS TECHNOLOGIES	0603739E	59	03	Volume 1 - 203
BASIC OPERATIONAL MEDICAL SCIENCE	0601117E	4	01	Volume 1 - 45
BIOLOGICAL WARFARE DEFENSE	0602383E	15	02	Volume 1 - 101
BIOMEDICAL TECHNOLOGY	0602115E	9	02	Volume 1 - 51
CLASSIFIED DARPA PROGRAMS	0603765E	61	03	Volume 1 - 239
COGNITIVE COMPUTING SYSTEMS	0602304E	14	02	Volume 1 - 95
COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS	0603760E	60	03	Volume 1 - 217
CYBER SECURITY INITIATIVE	0305103E	171	06	Volume 1 - 281
DEFENSE RESEARCH SCIENCES	0601101E	2	01	Volume 1 - 1
ELECTRONICS TECHNOLOGY	0602716E	22	02	Volume 1 - 153
INFORMATION & COMMUNICATIONS TECHNOLOGY	0602303E	13	02	Volume 1 - 65
MANAGEMENT HQ - R&D	0605898E	164	06	Volume 1 - 279
MATERIALS AND BIOLOGICAL TECHNOLOGY	0602715E	21	02	Volume 1 - 133
NETWORK-CENTRIC WARFARE TECHNOLOGY	0603766E	62	03	Volume 1 - 241
SENSOR TECHNOLOGY	0603767E	63	03	Volume 1 - 257
SMALL BUSINESS INNOVATION RESEARCH	0605502E	155	06	Volume 1 - 277

Program Element Title	Program Element Number	Line Item	Budget Activity	Page
SPACE PROGRAMS AND TECHNOLOGY	0603287E	41	03	Volume 1 - 191
TACTICAL TECHNOLOGY	0602702E	20	02	Volume 1 - 105

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
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
- 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
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*

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

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*

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

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*

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)* ***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	-	10.221	15.671

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*

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

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*

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

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*

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

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*

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

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*

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	-

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*

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 ***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.	7.078	11.815	-

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*

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.

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*

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.

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)** CYS-01 / *CYBER 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**
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.			

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)** CYS-01 / *CYBER SCIENCES*

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

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)** CYS-01 / *CYBER SCIENCES*

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 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)** ES-01 / *ELECTRONIC 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
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.			

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)** ES-01 / *ELECTRONIC SCIENCES*

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.			

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)** ES-01 / *ELECTRONIC SCIENCES*

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:

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)** ES-01 / *ELECTRONIC SCIENCES*

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) ***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	-	13.827	6.827

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)** ES-01 / *ELECTRONIC SCIENCES*

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

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)** ES-01 / *ELECTRONIC SCIENCES*

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)	8.000	4.027	-
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:***			

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)** ES-01 / *ELECTRONIC SCIENCES*

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)	8.094	-	-
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.			
Title: Optical Radiation Cooling and Heating in Integrated Devices (ORCHID)	4.255	-	-
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			

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)** ES-01 / *ELECTRONIC SCIENCES*

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.

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) MS-01 / *MATERIALS 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
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.

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)** MS-01 / *MATERIALS SCIENCES*

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 ***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.	5.159	6.500	10.200

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)** MS-01 / *MATERIALS SCIENCES*

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.			

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)** 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	18.591	23.352	30.970
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			

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)** MS-01 / *MATERIALS SCIENCES*

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
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
- 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
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
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
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
- 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	9.941	10.973	11.464
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,			

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
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 ***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.	9.489	8.000	3.197

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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)	-	3.500	2.500
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.			

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

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-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
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
- 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
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
- 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.			

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
- 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

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
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

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
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

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
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	-	-	21.000
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.			
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
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
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
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
- 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
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
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

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*

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 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*

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
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
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) ***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.	22.001	13.000	-

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-02 / *HIGH PRODUCTIVITY, HIGH-PERFORMANCE RESPONSIVE ARCHITECTURES*

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
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*

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
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
- 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
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
- 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
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
- 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

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
- 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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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
- 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

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
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

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
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

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
- 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

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
- 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

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
- 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:

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
- 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	15.949	6.697	-
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.			

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
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
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
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
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)	4.000	4.500	3.200
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.			
Title: LUSTER (Laser Ultraviolet Sources for Tactical Efficient Raman)	-	-	7.000
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			

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
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	5.000	2.000	2.000
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.			

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
- 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
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
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
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
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)* ***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.	20.960	-	-

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
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:

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*

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

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*

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

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*

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.			

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*

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

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*

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	-

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*

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	-	-

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*

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.

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 0602715E / *MATERIALS AND BIOLOGICAL 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	-	158.175	166.654	160.389	-	160.389	200.725	219.944	236.197	257.703	-	-
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	122.658	125.144	81.413	-	81.413	101.018	110.634	124.077	127.453	-	-
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	35.517	41.510	78.976	-	78.976	99.707	109.310	112.120	130.250	-	-

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 its objective is to develop material, biological and energy technologies that make possible a wide range of new military capabilities.

The major goal of the Materials Processing Technology project is to develop novel materials, materials processing and manufacturing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of materials including: structural materials and devices, functional materials and devices, and materials that enable new propulsion concepts for land, sea, and space vehicles and low distortion optical lenses.

The Biologically Based Materials and Devices project acknowledges the growing and pervasive influence of the biological sciences on the development of new materials, devices and processes, as well as the commensurate influence of materials, physics and chemistry on new approaches to biology and biochemistry. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the development of biochemical materials to maintain performance, the use of biology's unique fabrication capabilities to produce structures that cannot be made any other way, the development of manufacturing tools that use biological components and processes for material synthesis, the development of new cognitive therapeutics, understanding the complexity in biological systems, and exploration of neuroscience technologies.

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	166.067	166.654	179.383	-	179.383
Current President's Budget	158.175	166.654	160.389	-	160.389
Total Adjustments	-7.892	-	-18.994	-	-18.994
• Congressional General Reductions	-0.231	-			
• Congressional Directed Reductions	-5.724	-			
• Congressional Rescissions	-	-			
• Congressional Adds	9.000	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-6.173	-			
• SBIR/STTR Transfer	-4.764	-			
• TotalOtherAdjustments	-	-	-18.994	-	-18.994

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2013	FY 2014
Project: MBT-01: *MATERIALS PROCESSING TECHNOLOGY*		
Congressional Add: *BioFuels*	9.000	-
Congressional Add Subtotals for Project: MBT-01	9.000	-
Congressional Add Totals for all Projects	9.000	-

Change Summary Explanation

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

FY 2015: Decrease reflects the completion of 6.2 efforts in the Structural Materials and Coatings thrust. Demonstration efforts for this thrust area will continue in PE 0603766E, Project NET-02.

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING 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
MBT-01: *MATERIALS PROCESSING TECHNOLOGY*	-	122.658	125.144	81.413	-	81.413	101.018	110.634	124.077	127.453	-	-

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

A. Mission Description and Budget Item Justification

The major goal of the Materials Processing Technology project is to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of materials including structural materials and devices, functional materials and devices, low distortion optical lenses, and materials that enable new propulsion concepts for land, sea, and space vehicles.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Materials Processing and Manufacturing	12.750	24.300	21.784

Description: The Materials Processing and Manufacturing thrust is exploring new manufacturing and processing approaches that will dramatically lower the cost and decrease the time required to fabricate DoD systems. It will also develop approaches that yield new materials and materials capabilities that cannot be made through conventional processing approaches as well as address efficient, low-volume manufacturing.

FY 2013 Accomplishments:
- Continued development on the path to carbon fiber with 100% improvement in strength and 50% improvement in stiffness over today's state-of-the-art high-performance structure carbon fibers, and demonstrated fiber production at manufacturing scale.
- Developed and demonstrated rapid, robust manufacture processes with an end goal of 20% increase in key material properties, 50% reduction of cost over baseline, and 50% reduction in time over baseline.
- Established impartial manufacturing centers of expertise that provide capability to non-traditional suppliers for demonstration, testing, and qualification of new manufacturing technologies; assisted in transition to the supply chain; provided access to potential customers; and facilitated training.
- Performed virtual manufacturing system exercises that pass design, manufacture, and verification of a specific part through the entire chain.
- Demonstrated rapid qualification and certification methodologies that empirically optimize part qualification and employed probabilistic models for variability analysis and risk, with an end goal of 50% reduction in certification time and cost.

FY 2014 Plans:
- Validate predictive capability of process models on material properties and microstructure as well as component performance, quality level, and manufacturing effectiveness.

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop new probabilistic models and uncertainty quantification methodologies for rapid qualification. - Develop and demonstrate manufacturing assessment tools for select new manufacturing technologies. - Establish limits on lot size for additive manufacture of selected components that provide a 50% reduction in cost and time over standard fabrication baselines. - Establish a library of process models and manufacturing data to support model use and improvement. ***FY 2015 Plans:*** - Demonstrate integrated, physics-based, location-specific computational tools that predict the thermal history, residual stress, residual distortion, and microstructure of In718 alloys produced by direct metal laser sintering (DMLS). - Implement in-process quality assurance (IPQA) sensors and technology capable of capturing DMLS processing data, and initiate development of optimized capture of real time data at appropriate resolutions to forecast article quality. - Demonstrate operational phenomenological metallurgical models that link electron beam direct manufacturing (EBDM) process parameters to microstructure and material properties for location-specific prediction of ultimate tensile strength throughout a built structure. - Demonstrate automated X-Y-Z wire position control system based on real-time, fast rate, solid-state backscattered electron sensor system. - Simulate high fidelity probabilistic process window (including tails) for bonded composite structures using Monte Carlo techniques and a priori knowledge of process variables. - Complete verified 2D and 3D bonded composite pi-joint structure models. - Establish interoperable process-material model assessment framework, and curate and standardize a data management system to capture and store data from materials and manufacturing research.			
Title: Multifunctional Materials and Structures ***Description:*** The Multifunctional Materials and Structures thrust is developing materials, materials processing, and structures that are explicitly tailored for multiple functions and/or unique mechanical properties. Development efforts under this thrust include reactive structures that can serve as both structure and explosive for lightweight munitions, novel materials and surfaces that are designed to adapt structural or functional properties to environmental and/or tactical threat conditions, and new thin film material deposition processes to improve the performance of surface dominated properties (friction, wear, and membrane permeability). Additionally, this project will develop new computational tools that link material properties to physics across multiple length scales (from molecule to part) in order to provide the ability to model and exploit complexity, such as hierarchy and strongly correlated effects, in structural and functional materials. Examples of DoD applications that will benefit from these material developments include lower weight and higher performance aircraft, turbines with enhanced efficiency, erosion-resistant rotor blades, and high-temperature materials for operation in hypersonic environments. ***FY 2013 Accomplishments:***	17.000	22.665	15.366

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrated a lightweight desalination system that exploits a newly developed anti-fouling coating on an ultrafiltration membrane to achieve 75gph potable output from seawater with an overall power consumption of less than or equal to 10 W/gph. - Established techniques to deliver a high flux of gas-phase reactants to a surface at ambient pressure and temperature and demonstrated enhanced mobility of reactant molecules on a surface layer for material growth without bulk substrate heating. - Explored phenomena such as surface plasmon resonances to enable site-specific nucleation and growth of high-temperature coatings at room temperature. - Conducted small scale experiments that demonstrated the potential for maintaining a blast output enhancement of at least 4x while cutting explosive payload by 50% using reactive material structures. - Characterized computationally the load and strain rate effects on modulus of reactive cases as a function of microstructure, case thickness, and load path. - Verified that amorphous metal reactive structure composition and morphology can sustain loads in excess of 100,000 psi and at strain rates >10^3/sec. - Optimized fiber weave enforcement 3D architectures to sustain tensile, compressive, and hoop loads to > 100,000 psi and at strain rates > 10^3/sec. - Optimized composition, architecture, and impedance of fiber reinforcement weave and reactive matrix to "extrude" reactive constituents through reinforcement weave and produce activated, micron reactive particles. ***FY 2014 Plans:*** - Integrate flux, mobility and reactivity process components to validate low-temperature deposition of DoD-relevant thin film coatings that currently require high bulk temperature. - Quantify temporal and spatial stability of reactive species at ambient temperature for a DoD-relevant thin film coating in an integrated deposition system. - Initiate comprehensive local control approach to thin film synthesis. - Integrate fiber-reinforced reactive matrix and high-stiffness amorphous metals into reactive case structure and characterize dynamic mechanical response. - Demonstrate ability to survive penetration into reinforced concrete with a minimal amount of strain deformation. - Demonstrate survivability of impact into reinforced concrete at ballistic velocities. - Demonstrate scalability to low-rate manufacturing scales while maintaining blast enhancement of survivable materials over inert cased charge. ***FY 2015 Plans:*** - Experimentally validate computational models of low temperature diamond thin film growth. - Integrate in situ characterization techniques for real-time qualitative and quantitative analysis of growth processes. - Demonstrate deposition of diamond thin film challenge material on diamond single crystal or Si wafer at low temperature.			

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Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Reduce non-diamond carbon content to improve film quality and properties by adjusting process component parameters/ integration strategy.			
Title: Materials for Force Protection	25.573	26.159	22.649

Description: The Materials for Force Protection thrust is developing novel materials and materials systems that will greatly enhance performance against ballistic and blast threats including explosively formed projectiles (EFP) and shaped charges across the full spectrum of warfighter environments. Included in this thrust are novel topological concepts as well as entirely new structural designs that will afford enhanced protection and functionality, at reduced weight and/or cost.

FY 2013 Accomplishments:
- Scaled up transparent armor solution with multi-hit performance capability at weights equivalent to that of opaque armor.
- Demonstrated the ability to produce transparent armor in military relevant sizes while maintaining optical and ballistic performance characteristics.
- Initiated development of capability to accurately account for and track load paths during an underbody blast event and provide material properties and energy management mechanisms to meet survivability objectives.
- Continued to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and vehicles.
- Performed validation testing of optimized advanced armor solutions that exploit the high-performance characteristics of low-cost materials using unique combinations of material composition and topology.
- Developed and demonstrated the high-risk manufacturing methods to transition the advanced armor technologies from laboratory scale into large-scale manufacturing and quality control processes that provide a marinized armor solution.
- Initiated effort to identify critical parameters that will permit scaling of subscale ballistic modeling and testing into the regime of military relevance.
- Established and used mechanics-based models and simulations to guide the design, development, and fabrication of ballistic armor.
- Continued integration of ballistic and blast energy management mechanisms into material systems and incorporated into candidate armor material systems for optimization against specific threats.

FY 2014 Plans:
- Integrate material properties and energy management mechanisms into ballistic armor materials optimized for single threat defeat in each regime (bullet, frag, EFP) to meet survivability objectives.
- Demonstrate at least 50% enhancement in opaque vehicle ballistic armor performance in each regime (bullet, frag, EFP) for single threats over state-of-the-art fielded designs.
- Conduct study, based on single threat results, to establish feasibility of achieving 2x enhancement in opaque vehicle ballistic armor performance for multiple threats.

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Continue to identify and evaluate promising new armor concepts from non-traditional organizations both for military personnel and vehicles. - Demonstrate >2x enhancement in energy absorption capability of candidate tactical vehicle materials over currently employed materials. - Determine feasibility to reduce effects of localized dynamic loading in an underbody blast event by 50% over state-of-the-art. - Determine feasibility to reduce effects of global impulse in an underbody blast event by 50% over state-of-the-art. ***FY 2015 Plans:*** - Demonstrate at least 50% enhancement in opaque vehicle ballistic armor performance for combined bullet-frag threats over state-of-the-art fielded designs. - Demonstrate capability, based on small arms threat results, to achieve at least 50% enhancement in opaque vehicle ballistic armor performance to defeat bullets from heavier weapons. - Develop capability, based on results of feasibility study, to achieve 2x enhancement in opaque vehicle ballistic armor performance for multiple threats in an integrated armor design. - Incorporate the best promising new armor concepts from non-traditional organizations into integrated ballistic armor design and demonstrate performance. - Develop and demonstrate ability of monohull design to spread impulsive load from enhanced (>2x impulsive load) underbody blast and prevent breach at equivalent weight to current underbody structures. - Integrate energy absorbing materials and components into passive hierarchical energy absorbing systems characteristic of various vehicle weight classes and demonstrate capability to reduce by >2x the combined effects of local and global impulse in underbody blast events. - Demonstrate capability to reduce by >2x the combined effects of local and global impulse in active counter impulse systems characteristic of various vehicle weight classes in underbody blast events. - Demonstrate capability to reduce by >4x the effects of both local and global impulse by combining hierarchical passive energy absorbing and active counter impulse systems into integrated systems characteristic of various vehicle weight classes in underbody blast events.			
Title: Functional Materials and Devices ***Description:*** The Functional Materials and Devices thrust will address problems with high-performance functional optical materials and components development. Improved materials require deliberate control at the scale of the relevant phenomena. This thrust will leverage the advanced fabrication capabilities currently available, coupled with design of optical materials and component structure, to drive functional materials to high performance for soldier-centric DoD applications by design. Novel optical materials exploiting three-dimensional degrees of freedom to increase wavefront control, and flexible transparent displays are examples of materials in which design of structure at the scale of the critical phenomena can have significant impact on	6.013	12.985	6.000

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
their performance. To provide organic information, surveillance, and reconnaissance to the warfighter that greatly enhances awareness, security, and survivability, the capability for wearable (i.e., ultra-low size, weight, and power) systems with specific functionality will be developed. These functions include holistic sensor integration, immersive telepresence, foveated imaging, remote reconnaissance and piloting, targeting assistance, and supplementary data overlay. This thrust will also explore newly emerging areas where structure may play an important role. ***FY 2013 Accomplishments:*** - Investigated processes for integrating nano-polarizers with rigid gas permeable contact lenses. - Initiated user testing of zoom contact lens. - Evaluated current state-of-the-art-low profile heads-up display components. - Fabricated wide field of view compact camera components with low size, weight, and power. - Developed software design components supporting the joint optimization of optical and algorithms degrees of freedom. - Investigated alternative algorithms for computer-enhanced vision. ***FY 2014 Plans:*** - Demonstrate and conduct user testing of hands-free zoom capability. - Demonstrate and conduct user testing of integrated head-mounted display with eye tracking. - Assemble and test wide field of view compact camera. - Demonstrate integrated software environment for image collection and processing. ***FY 2015 Plans:*** - Design soldier-wearable full-sphere, high-resolution visible and infrared camera array platform with integrated supplemental sensors. - Continue development of immersive displays with rapid head and eye tracking, 3D augmented audio, and advanced wearable sensor interfaces. - Demonstrate expanded situational awareness enhancements in training, reconnaissance, live mission, and after-action review. - Demonstrate an optimized collaborative interface for rapid information dissemination to coordinate unit operations in combat.			
Title: Manufacturable Gradient Index Optics (M-GRIN) ***Description:*** The Manufacturable Gradient Index Optics (M-GRIN) program seeks to advance the development of GRIN lenses from a Technology Readiness Level (TRL) 3 to a Manufacturing Readiness Level (MRL) 6. The program will expand the application of gradient index optics (GRIN) by providing compact, lightweight, and cost-effective lenses with controlled dispersion and aberrations that will replace large assemblies of conventional lenses. The ability to create entirely new optical materials and surfaces creates the potential for new or significantly improved military optical applications, such as solar concentrators, portable designators, highly efficient fiber optics, and imaging systems. The program also seeks to extend GRIN manufacturing	17.223	11.800	7.814

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Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
technologies to glass, ceramic, and other inorganic materials in order to allow for small, lightweight, customized optical elements for mid-wave and long-wave infrared (MWIR and LWIR) applications. A key component of the program is to develop new design tools that enable optics designers to incorporate dynamic material properties, fabrication methods, and manufacturing tolerances. The integration of new materials, design tools, and manufacturing processes will enable previously unattainable 3-D optical designs to be manufactured. This new manufacturing paradigm will enable flexible production of GRIN optics in quantities of one unit to thousands of units. ***FY 2013 Accomplishments:*** - Designed and fabricated tunable lens from variable refractive index polymers. - Developed and demonstrated fusion of multiple layers of optical ceramic into preforms (visible and IR-transparent). - Designed, built, and measured prototype IR chalcogenide lens using previously developed GRIN lens design tools and metrology methods. - Demonstrated initial GRIN design tools add-on modules to allow GRIN design for commercially available optical design software intended for advanced users; modules incorporate specific manufacturing constraints and tolerances to allow for realistic designs. - Designed and fabricated a GRIN-based optical system to retrofit an existing or new platform with less weight and/or fewer optical elements. ***FY 2014 Plans:*** - Advance MRL yields and rapid redevelopment cycles. - Demonstrate rapid redevelopment/prototype manufacturing capability by producing multiple GRIN lenses from the same manufacturing process. - Use prototype designs to demonstrate breadth of improved DoD-relevant parameters/properties (wide field-of-view, f-number, bandwidth, etc.) in manufactured optical components. - Expand IR metrology of program materials. - Characterize thermal properties of M-GRIN materials and mitigate effect on optical performance. - Expand design tools to add 3D and arbitrary gradients as well as improve computational efficiency. ***FY 2015 Plans:*** - Complete GRIN lens production scale-up and demonstrate process control as measured against target yield and cost, to enable sustainable manufacturing. - Demonstrate intermediate volume capability through repeatable production of several small lots. - Upgrade design tools and expand potential user pool from advanced to mid-level optical designers, through upgrades and improvements of the GRIN design modules, to provide user-friendly interface for customers.			
Title: Structural Materials and Coatings	12.201	12.500	-

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: The Structural Materials and Coatings thrust is exploring and developing new materials that will provide enhanced structural and/or surface properties for DoD applications. Included are approaches that avoid corrosion through engineered material, provide superior strength at greatly reduced material density, provide the basis for a new generation of structural composite and submarine propeller materials, and enable prolonged lifetimes for DoD systems and components. The goal of the Hybrid Multi Material Rotor Full-Scale Demonstration (HyDem) program, an outgrowth of the Structural Materials and Coatings effort's Hybrid Multi Material Rotor (HMMR) program, is to dramatically improve U.S. Navy submarine superiority. The HyDem program will design, manufacture, and supply the Navy with a novel component for integration into a new construction Virginia Class Submarine. The Navy will evaluate this component in sea trials. If successful, it is envisioned that the Navy will integrate this design change into the future development of the Virginia Class and Ohio Replacement Submarines, and possibly back-fit previously constructed Virginia Class Submarines. Beginning in FY2015 this program will be funded from PE 0603766E, Project NET-02, Maritime Systems. ***FY 2013 Accomplishments:*** - Completed Coupling Software Environment (CSE) development to enable strong coupling of the hybrid multi-material rotor (HMMR) domain codes required for time-accurate performance predictions of multi-material rotors. - Manufactured and evaluated complex structural test specimens demonstrating ability to design robust products with multi-material technology. - Developed a design for a scaled multi-material propeller or rotor for testing on a large-scale vehicle. - Designed and fabricated representative articles for large-scale propeller or rotor blades for mechanical evaluations. - Developed manufacturing process plans for large-scale vehicle propeller or rotor blades. ***FY 2014 Plans:*** - Complete concept design, demonstrating the ability to scale from 1/4-scale HMMR to full-scale component. - Complete preliminary design, demonstrating that the design accommodates stated performance parameters. - Perform shock test of scaled components. - Develop manufacturing process plans for full-scale components. - Deliver large-scale rotor to the Navy for in-water testing and assessment.			
Title: Reconfigurable Structures ***Description:*** In the Reconfigurable Structures thrust, new combinations of advanced materials, devices, and structural architectures are being developed to allow military platforms to move, morph, or change shape for optimal adaptation to changing mission requirements and unpredictable environments. This includes the demonstration of new materials and devices that will enable the military to function more effectively in the urban theater of operations. Another focus is to build synthetic versions of	20.598	14.735	7.800

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Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
biological systems that exhibit strong reversible adhesion via van der Waals forces, magnets, or microspines to scale vertical surfaces without using ropes or ladders. In addition, this thrust will develop a principled, scientific basis for improved robotic ground mobility, manipulation, and autonomy, and leverage these results to develop and demonstrate innovative robot design tools, fabrication methods, and control methodologies. ***FY 2013 Accomplishments:*** - Demonstrated that a soldier with operationally relevant equipment (250lb upper limit) can robustly climb 25-foot walls built from diverse materials using gecko nanoadhesive. - Transitioned additional Z-MAN prototype sets of gecko nanoadhesive to the services. - Designed backing tile and microwedge materials, modeled physical characteristics of materials and fabrication processes, and developed processing techniques and tooling capabilities to demonstrate low-volume manufacturing capability of gecko nanoadhesive. - Applied novel design tools to reduce design time of robots to include user-guided evolution of structures and controller, and automated morphological design processes. - Applied fabrication methods to produce robot components at substantial (> 50% lower) cost savings, to include printing and assembly by folding of a walking robot, and fabrication of a soft pneumatically actuated robot. - Demonstrated new control algorithms on real robots, including mobility efficiency improvements of at least 2x, prevention of rollover by reasoning about vehicle dynamics, and a touch-sensitive arm to reach through a cluttered workspace. - Built and demonstrated robots with higher-performance mobility, including biped robots that can walk on previously inaccessible rough terrain, and robots that locomote at speeds at least twice as fast as current platforms. - Developed high efficiency actuators, e.g., mechanical power factor correctors; mechanical, hydraulic, and electrical approaches for lightweight, high-power, variable-ratio transmissions; and switching modulation for hydraulic actuators, stepper motors, and purely mechanical systems. ***FY 2014 Plans:*** - Complete design of actuation system for a humanoid robot, including bench-top testing of high-risk components and/or subsystems. - Demonstrate actuation of a humanoid robot that increases its energy efficiency by 20x, using the same kinematic structure, energy source, computing, and low-level control software. - Demonstrate advanced energy-efficiency improvement actuation approaches by quantitative analysis and/or simulation. ***FY 2015 Plans:*** - Validate advanced energy-efficiency improvement actuation approaches by experimentation.			
Title: Alternate Power Sources	2.300	-	-

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-01 / *MATERIALS PROCESSING TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: The Alternate Power Sources thrust evaluated materials and technologies that could utilize alternative power sources with the potential to provide significant strategic and tactical advantages to the DoD. A consistent DoD need continues to be greater efficiency in a portable form factor. For example, portable photovoltaic (PV) technologies could meet this need using low-cost manufacturing approaches. ***FY 2013 Accomplishments:*** - Demonstrated portable PV devices that produce at least 80% of their specified electrical output after the equivalent of one year of sunlight and after exposure to environmental hazards such as punctures, humidity, and temperature extremes. - Demonstrated portable PV devices that function at greater than or equal to 16% power conversion efficiency. - Designed portable PV devices that allow for greater than or equal to $4 per Watt manufacturing. - Demonstrated PV devices that have density of less than or equal to 1500 grams per square meter.			
Accomplishments/Planned Programs Subtotals	113.658	125.144	81.413

	FY 2013	FY 2014
Congressional Add: BioFuels ***FY 2013 Accomplishments:*** This effort will transition BioFuels technology developed under PE 0602715E.	9.000	-
Congressional Adds Subtotals	9.000	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*	

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
MBT-02: *BIOLOGICALLY BASED MATERIALS AND DEVICES*	-	35.517	41.510	78.976	-	78.976	99.707	109.310	112.120	130.250	-	-

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

A. Mission Description and Budget Item Justification

This project acknowledges the growing and pervasive influence of the biological sciences on the development of new DoD capabilities. This influence extends throughout the development of new materials, devices, and processes and relies on the integration of biological breakthroughs with those in engineering and the physical sciences. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the use of biology's unique fabrication capabilities to produce structures that cannot be made any other way, the application of materials in biological applications, and the development of manufacturing tools that use biological components and processes for materials synthesis. This project also includes major efforts aimed at integrating biological and digital sensing methodologies and maintaining human combat performance despite the extraordinary stressors of combat. Finally, this thrust will develop new cognitive therapeutics, investigate the role of complexity in biological systems, and explore neuroscience technologies.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Neuroscience Technologies	9.000	11.917	16.000

Description: The Neuroscience Technologies thrust leverages recent advances in neurophysiology, neuro-imaging, cognitive science, molecular biology, and modeling of complex systems to sustain and protect the cognitive functioning of the warfighter faced with challenging operational conditions. Warfighters experience a wide variety of operational stressors, both mental and physical, that degrade critical cognitive functions such as memory, learning, and decision making. These stressors also degrade the warfighter's ability to multitask, leading to decreased ability to respond quickly and effectively. Currently, the long-term impact of these stressors on the brain is unknown, both at the molecular and behavioral level. This thrust area will create modern neuroscientific techniques to develop quantitative models of this impact and explore mechanisms to protect, maintain, complement, or restore physical and cognitive functioning during and after exposure to operational stressors. In addition, new approaches for using physiological and neural signals to make human-machine systems more time efficient and less workload intense will be identified, developed, and evaluated. This thrust area will have far-reaching implications for both current and future military operations, with the potential to protect and improve physical and cognitive performance at the individual and group level both prior to and during deployment.

FY 2013 Accomplishments:

- Integrated human data on stress genes to determine human stress-related gene networks for targeting interventions.

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Translated genes and networks identified in animals to humans using high throughput molecular data from population-based studies. - Determined biomarkers of alertness in active duty personnel with psychological health problems/traumatic brain injury. - Correlated clinical and psychological profiles of patients with post-traumatic stress disorder to neural networks, neurochemicals and behavior for biomarker identification. - Identified objective measures of physical and cognitive states through the application of integrated analytics and advanced computational techniques. ***FY 2014 Plans:*** - Determine genetic, epigenetic, and proteomic changes underlying vulnerability to poor decision making in humans. - Develop tools and metrics for evaluating individual and group performance during close quarters combat training and other operationally relevant training scenarios. - Exploit advances in complexity theory and predictive models of the brain and investigate new modeling methods to develop tools and techniques that can characterize and improve cognitive performance under stress at both the individual and group level. ***FY 2015 Plans:*** - Exploit new data and recent advances in functional imaging, neurophysiology recording, molecular and neural imaging, cognitive science, and biology in conjunction with emerging solutions in neurally enabled human-machine interface technologies to characterize dynamics of human cognitive functions such as memory, learning, and decision making. - Initiate development of a unifying cross layer system model of the brain characterizing functions, dynamics, molecular and anatomical structure of the brain and their inter-relationships. - Exploit recent advances in computational analysis, systems identification, data intensive computing, and statistical inference methods to develop computational tools and collaborative research platform for rapid analysis, validation, and integration of computational models of the brain. - Initiate development of a new hierarchical framework for modeling and simulating structure, function and emergent behavior in complex biological systems and bionetworks. - Create engineered intestinal biomes that respond to changes in critical neurotransmitter concentrations that control sense of well-being and satiety as well as those that influence intestinal health and nutrient uptake.			
Title: BioDesign ***Description:*** BioDesign will employ system engineering methods in combination with biotechnology and synthetic chemical technology to create novel beneficial attributes. BioDesign mitigates the unpredictability of natural evolutionary advancement primarily by advanced genetic engineering and molecular biology technologies to produce the intended biological effect. This thrust area includes designed molecular responses that increase resistance to cellular death signals and improved computational methods for prediction of function based solely on sequence and structure of proteins produced by synthetic biological systems.	10.824	11.438	19.354

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Development of technologies to genetically tag and/or lock synthesized molecules would provide methods for prevention of manipulation ("tamper proof" synthetic biological systems). This thrust will also develop new high-throughput technologies for monitoring the function of cellular machinery at the molecular level and the response(s) of that machinery to physical, chemical, or biological threats. While conventional approaches typically require decades of research, new high-throughput approaches will permit rapid assessment of the impact of known or unknown threats on identified biomolecules and cell function. ***FY 2013 Accomplishments:*** - Developed novel genomic memory security technologies to sense environmental conditions and record them for future readout in the genome. - Developed novel genomic circuits to identify microorganisms that were passed through the gut of live animals to test virulence. - Developed lock-key device to permit research with protected or proprietary microorganisms only under authorized conditions. ***FY 2014 Plans:*** - Demonstrate functionality of genomic security technologies in two or more different commercially relevant microbes used for production of biocommodities. - Evaluate high-throughput methods that have the potential to map intracellular proteins. - Develop a path to detect intracellular components and events that are present in quantities ranging from fifty to thirty million copies per cell. - Develop a plan to detect intracellular molecules with masses ranging from fifty to two hundred thousand Daltons. - Initiate development of high throughput analytical equipment to measure the concentration of >1000 proteins simultaneously. ***FY 2015 Plans:*** - Utilize high throughput approaches to characterize intracellular components and mechanistic interactions that reveal the effects of challenge compounds on intracellular machinery. - Demonstrate high throughput methods using cells of human origin. - Demonstrate the ability to identify intracellular components and events that occur hours after the application of a challenge compound. - Demonstrate the ability to localize relevant molecules and events to one intracellular compartment (membrane, nucleus, or cytoplasm) upon the application of a challenge compound. - Reconstruct and confirm greater than 20 percent of the molecules and mechanistic events that comprise the canonical mechanism of action for a demonstration compound which has been applied to cells. - Initiate development of platform technologies to characterize molecular responses between members of a complex microbiome. - Create algorithms to model the laws of communication within complex multi-cellular communities with the objective to predict how a community responds to new conditions/threats.			

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Appropriation/Budget Activity 0400 / 2	**R-1 Program Element (Number/Name)** PE 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiate development of high-throughput arrayed microbiome-based technologies to identify novel secondary-metabolite antibiotics against pathogenic bacteria that have evolved multi-drug resistance.			
Title: Living Foundries	10.310	18.155	28.122

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 enable new solutions and enhancements to military needs and capabilities. Ultimately, Living Foundries aims to provide game-changing manufacturing paradigms for the DoD, enabling distributed, adaptable, on-demand production of critical and high-value materials, devices, and capabilities in the field or on base. Such a capability will decrease the DoD's dependence on tenuous material supply chains vulnerable to political change, targeted attack, or environmental accident.

Research thrusts will focus on the development and demonstration of open technology platforms, or bioproduction pipelines, that integrate the tools and capabilities developed in PE 0601101E, TRS-01 to prove out capabilities for rapid (months vs. years) design and construction of new bio-production systems for novel materials. The result will be an integrated, modular infrastructure across the areas of design, fabrication, debugging, analysis, optimization, and validation -- spanning the entire development life-cycle and enabling the ability to rapidly assess and improve designs. Integrated processes developed in this program will translate into significant performance improvements and cost savings for the production of advanced materials, biological reporting systems, and therapeutics. These technologies will ultimately result in on-demand, customizable, and distributed production of strategic materials and systems. Key to success will be tight coupling of computational design, fabrication of systems, debugging using multiple characterization data types, analysis, and further development such that iterative design and experimentation will be accurate, efficient and controlled. Demonstration platforms will be challenged to build a variety of DoD-relevant, novel molecules and chemical building blocks with complex functionalities, such as synthesis of advanced, functional chemicals, materials precursors, and polymers (e.g., those tolerant of harsh environments).

FY 2013 Accomplishments:

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated integration of fundamental tools and capabilities developed in PE 0601101E, TRS-01 to speed the design, build, and test loop of biological manufacturing, and start bio-foundries development. - Demonstrated ability to speed the design, engineering and production of multiple new bioproducts by >7.5X (from years to months). - Began development and refinement of tools and capabilities to translate designs across multiple platforms and biological systems; demonstrated ability to port a refactored gene cluster across multiple organisms while retaining function. - Began to standardize fabrication, characterization, and test processes on a common infrastructure to enable modularity and flexibility for design and construction of new systems. - Began development of new computational algorithms to perform quality control and evaluate screening data to automatically inform the redesign and optimization of novel biological production systems. - Began initial demonstrations of ability to design, build and test materials production pathways that are difficult or impossible to synthesize using known mechanisms. - Validated the concept of computational design and construction for a novel bio-synthetic pathway for acetaminophen, which was not previously obtainable through biosynthesis. ***FY 2014 Plans:*** - Continue standardization, integration, and automation of the fundamental tools and capabilities developed in PE 0601101E, TRS-01 into a readily adoptable and adaptable biomanufacturing platform. - Begin to integrate data streams (using previously developed computation algorithms and software) from fabrication, quality control and characterization tools to provide a comprehensive debugging capability and to enable forward design. - Begin to demonstrate, test, and evaluate the extent of design-build-test cycle compression using integrated platforms to engineer new bioproduction systems. - Initiate development of rapid design and prototyping infrastructure pipelines, including initial system integration and process optimization. - Begin testing the ability of integrated infrastructure pipelines to demonstrate rapid, improved prototyping of DoD-relevant molecules. ***FY 2015 Plans:*** - Demonstrate the ability of each infrastructure pipeline to rapidly generate DoD-relevant molecules. - Expand the capabilities of the rapid design and prototyping infrastructure to target molecules and chemical building blocks that are currently inaccessible using traditional synthesis mechanisms. - Complete proof-of-concept demonstrations of component technologies developed under PE 0601101E, TRS-01 that accelerate the design-build-test cycle. - Expand access and experimental scale to promote the production capabilities of rapid design and prototyping facilities infrastructure.			

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Begin establishing the efficacy of the integrated design-build-test-debug feedback cycle for forward design and rapid optimization of novel, currently inaccessible molecules via the prototyping facility's established processes.			
Title: SAEBR (Surprise Avoidance in Engineering Biology Research) ***Description:*** There is a national security need to assess and address the capabilities enabled by enhanced engineering biology technologies, and to protect the tools used for the facile engineering of biological systems. The Surprise Avoidance in Engineering Biology Research (SAEBR) program will enlist leading experts across the engineering biology field to assess potentially surprising/unanticipated applications enabled by newly designed tools, technologies, and methodologies as well as their potential for misuse. Applied research in this area will focus on understanding how current tools and technologies may be safeguarded against potential misuse. ***FY 2015 Plans:*** - Begin evaluating how emerging engineering biology technologies can be safeguarded against misuse. - Begin identifying molecular signatures that can distinguish "natural" organisms from synthetic strains.	-	-	5.500
Title: Adaptive Immunomodulation-Based Therapeutics ***Description:*** The Adaptive Immunomodulation-Based Therapeutics program will develop platform technologies that can interrogate and define the biological pathways leading to an immune response with the goal of developing and demonstrating new therapeutic interventions. One approach to achieve this capability will require the development of new tools to stimulate and measure responses of the nervous system in order to map the bioelectric code that controls the immune response as well as other critical organ functions. This program will also develop capabilities for serial measurements of metabolic state to identify correlates for health and early detection of disease. An additional approach involves characterizing the host response in patients with severe infections, and translating this response into a quantitative framework that can be used to guide modulation of the immune response. A further line of effort will pursue a detailed understanding of infectious diseases circulating in a community, with an aim to build capacity for the response to a crisis through managing current infectious disease challenges. The effort will employ sophisticated laboratory testing to evaluate the evolution of pathogens. Test beds in communities will be developed to evaluate the predictive algorithms by tracking infections in a community; influenza is an example of an infection that will be monitored. Advances made under the Adaptive Immunomodulation-Based Therapeutics program will improve our response capability against severe infectious diseases and biological threats and offer new avenues for treating disease with no available drugs, such as multiple drug resistant organisms. The ultimate goals for the Adaptive Immunomodulation-Based Therapeutics program are to enable an autonomous and continuous sense and response capability to regulate the human immune response and to develop decision support tools that help manage infectious diseases in a community. It is anticipated	-	-	10.000

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
that these capabilities will ultimately provide enhanced protection against injury, enable life-saving rescue from hyper-immune activity, and stimulate advances in regenerative medicine. ***FY 2015 Plans:*** - Correlate proteome levels and ratios with phenotype data to identify new biomarkers for human performance, injury, and infection. - Characterize the host response to severe infections, particularly severe respiratory infections and synthesize this information into a useable format, so that it can guide clinical interventions. - Develop capabilities to characterize the neural-immune interface, including real-time measurement of biomarkers and identification of novel, druggable targets for neural-immune modulation. - Develop test beds to evaluate the spread of infectious diseases in a community, with an initial focus on influenza and drug-resistant bacterial infections. - Develop model and decision support tools that help to manage these infections in a community.			
Title: Blood Pharming ***Description:*** The Blood Pharming program developed an automated culture and packaging system that yields transfusable levels of universal donor red blood cells (RBCs) from progenitor cell sources. The program produced 100 units of universal donor (Type O negative) RBCs per week for eight weeks in an automated closed culture system using a renewing progenitor population, and demonstrated a two hundred million-fold expansion of progenitor cell populations to mature RBCs. The program capitalized on advances in cell differentiation, expansion, and bioreactor technology developed early in the program. The Blood Pharming effort provides a safe donorless blood supply that is the functional equivalent of fresh donor cells, satisfying a large battlefield demand and reducing the logistical burden of donated blood in theater. ***FY 2013 Accomplishments:*** - Demonstrated fully integrated prototype instrument for medium-scale commercialized in vitro blood production. - Established protocols to ensure protection of blood supply and to enable rapid response in emergency scenarios. - Expanded value of in vitro blood product by enabling modification of red blood cells for therapeutic benefit. - Developed and transferred methods to enhance expansion of red blood cell precursors for continuous cell production in bioreactor-based culture. - Demonstrated successful grafting of modified progenitor cells into animal with subsequent establishment of robust in vivo production of modified mature red cells.	3.214	-	-
Title: Maintaining Combat Performance	2.169	-	-

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 0602715E / *MATERIALS AND BIOLOGICAL TECHNOLOGY*	**Project (Number/Name)** MBT-02 / *BIOLOGICALLY BASED MATERIALS AND DEVICES*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: The Maintaining Combat Performance thrust utilized breakthroughs in biology and physiology to sustain the peak physical and cognitive performance of warfighters operating in extreme conditions. Today, warfighters must accomplish their missions despite extraordinary physiologic stress. Examples of these stressors include temperature extremes (-20 degrees F to 125 degrees F), oxygen deficiency at high altitude, personal loads in excess of 100 lbs., dehydration, psychological stress, and even performance of life-sustaining maneuvers following combat injury. Not only must troops maintain optimum physical performance, but also peak cognitive performance. This includes the entire spectrum from personal navigation and target recognition, to complex command control decisions and intelligence synthesis. The Maintaining Combat Performance thrust leveraged breakthroughs in diverse scientific fields in order to mitigate the effects of physiological stress on warfighter performance in harsh combat environments. ***FY 2013 Accomplishments:*** - Developed an inhaled nitric oxide gas derivative (ENO) that improves O2 delivery and physical performance at altitude, and developed portable delivery system. - Demonstrated with large animal studies (sheep, swine) that lead compound ENO stabilized physiologic status and improved oxygen utilization under high altitude simulation. - Improved cerebral oxygenation in human subjects in hypoxic conditions (12% O2) with the treatment of inhaled ENO. - Completed field study of combined aminophylline and methazolamide therapy that showed improvement in blood oxygen saturation in human subjects.			
Accomplishments/Planned Programs Subtotals	35.517	41.510	78.976

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 0602716E / *ELECTRONICS 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	-	192.349	233.469	179.203	-	179.203	183.439	184.458	187.536	192.637	-	-
ELT-01: *ELECTRONICS TECHNOLOGY*	-	192.349	233.469	179.203	-	179.203	183.439	184.458	187.536	192.637	-	-

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 its objective is to develop electronics that make a wide range of military applications possible.

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

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

This project has five major thrusts: Electronics, Photonics, MicroElectroMechanical Systems, Architectures, Algorithms, and other Electronic Technology research.

Exhibit R-2, RDT&E Budget Item Justification: PB 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 0602716E / *ELECTRONICS TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	222.416	243.469	254.104	-	254.104
Current President's Budget	192.349	233.469	179.203	-	179.203
Total Adjustments	-30.067	-10.000	-74.901	-	-74.901
• Congressional General Reductions	-0.283	-			
• Congressional Directed Reductions	-26.166	-10.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	1.903	-			
• SBIR/STTR Transfer	-5.521	-			
• TotalOtherAdjustments	-	-	-74.901	-	-74.901

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 reduction for program growth.

FY 2015: Decrease reflects drawdown of several efforts prior to transition: Adaptive RF Technology, NEXT, Micro PNT, Microscale Power Conversion and POEM.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Terahertz Electronics	15.600	15.020	6.100

Description: The Terahertz Electronics program is developing the critical semiconductor device and integration technologies necessary to realize compact, high-performance microelectronic devices and circuits that operate at center frequencies exceeding 1 Terahertz (THz). There are numerous benefits for electronics operating in the THz regime and new applications in imaging, radar, communications, and spectroscopy. The Terahertz Electronics program is divided into two major technical activities: Terahertz Transistor Electronics that includes the development and demonstration of materials and processing technologies for transistors and integrated circuits for receivers and exciters that operate at THz frequencies; and Terahertz High Power Amplifier Modules that includes the development and demonstration of device and processing technologies for high power amplification of THz signals in compact modules.

FY 2013 Accomplishments:

- Achieved key device and integration technologies to realize compact, high performance electronic circuits operating beyond 0.85 THz.

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Developed key device and integration technologies to realize compact, high performance electronic circuits operating beyond 0.85 THz. - Completed device, integration, and metrology technologies to enable the manufacture of microsystems, such as heterodyne detectors, between 0.67 and 0.85 THz for advanced communications and radar applications at sub-millimeter wave frequencies. - Initiated multiple circuit implementations for applications between 0.67 THz and 0.85 THz, including passive structures required for signal handling at sub-mm-wave frequencies. - Developed measurement techniques for verifying circuit capability above 0.85 THz and calibrated these methods in a laboratory environment. ***FY 2014 Plans:*** - Complete circuit demonstrations between 0.67 THz and 0.85 THz, including high power amplifiers and integrated circuits. - Improve process yield of 0.67 THz transistors and demonstrate key building blocks for 0.67 THz heterodyne detectors and sensors. - Complete design and initiate fabrication of a 1.03 THz vacuum amplifier. ***FY 2015 Plans:*** - Complete measurements of receiver/exciter technologies at and above 0.67 THz. - Demonstrate oscillator circuits at 1.03 THz. - Demonstrate prototype THz transceiver link using THz Indium Phosphide (InP) technology. - Demonstrate improved thermal performance of vacuum amplifier for high duty cycle operation at THz frequencies.			
Title: Adaptive Radio Frequency Technology (ART) ***Description:*** There is a critical ongoing military need for flexible, affordable, and small size, weight and power (SWaP) real-time-adaptable military electromagnetic interfaces. The Adaptive Radio Frequency Technology (ART) program will provide the warfighter with a new, fully adaptive radio platform capable of sensing the electromagnetic and waveform environment in which it operates, making decisions on how to best communicate in that environment, and rapidly adapting its hardware to meet ever-changing requirements, while simultaneously significantly reducing the SWaP of such radio nodes. ART technology will also provide each warfighter, as well as small-scale unmanned platforms, with compact and efficient signal identification capabilities for next-generation cognitive communications, and sensing and electronic warfare applications. ART technology will also enable rapid radio platform deployment for new waveforms and changing operational requirements. The project will remove the separate design tasks needed for each unique Radio Frequency (RF) system, which will dramatically reduce the procurement and sustainment cost of military systems. ART aggregates the Feedback Linearized Microwave Amplifiers program, the Analog Spectral Processing program, and Chip Scale Spectrum Analyzers (CSSA) program, and initiates new thrusts in Cognitive Low-energy Signal Analysis and Sensing Integrated Circuits (CLASIC), and Radio-Frequency Field-Programmable Gate Arrays (RF-FPGA).	25.494	26.949	20.423

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Demonstrated highly linear time delay unit monolithic microwave integrated circuit for beam-steering applications in wideband phased arrays. - Demonstrated micro electro-mechanical systems (MEMS)-based channelized RF receiver topology for use in high-speed spectrum sensing applications from 0.02 - 6 gigahertz (GHz) with a scan rate > 5 terahertz per second. - Demonstrated world's first signal classification application-specific integrated circuit for the purpose of signal classification. Power consumption is sufficiently low to allow 170 hours of continuous classification on a single charge of a typical smartphone battery. - Demonstrated initial hardware implementations of developed signal recognition concepts/techniques. - Demonstrated simulations of direction-of-arrival hardware with 1.7 picoJoule/operation, which is 2 orders of magnitude lower than conventional processors. - Developed efficient and robust computer-aided design optimization algorithms for RF-FPGA programming including development of an emulation board for demonstrating these concepts. - Demonstrated usage of MEMS switches for reconfiguration of piezoelectric resonators/filters. - Demonstrated multi-channel filter manifold design showing the capability for switching resonators in and out of a filter for near-arbitrary transfer function control. - Developed flexible and programmable hybrid phase-locked loop with frequency tuning range up to 19 GHz. - Completed DC-to-20 GHz circuit for military applications, with both coarse- and fine-grained on-the-fly reconfigurability, all on a single monolithic integrated circuit fabricated in a commercial foundry process. - Demonstrated novel phase change material switches for use in RF-FPGAs with insertion loss <0.15 dB out to 50 GHz and < 0.5 dB out to 100 GHz with isolation > -10 dB over the full 100 GHz.			
FY 2014 Plans: - Demonstrate reconfigurable RF circuit (RF-FPGA) technologies at the component and system levels along with the necessary computer-aided design approaches. - Demonstrate the applicability of one RF hardware design for 5 different application spaces, as a prototype for how ART technology can lead the way to life-cycle cost reduction. - Demonstrate advanced concepts for signal recognition at the hardware level and initiate plans for transitioning these approaches to relevant DoD systems. - Demonstrate applicability of tunable filters for dynamic frequency allocation in a fielded radio system.			
FY 2015 Plans: - Demonstrate final circuit design technologies including microwave switches, frequency synthesis and RF functionality.			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate a fully reconfigurable RF filter element with serial addressing of the components in an appropriate package form factor. - Optimize the RF phase-change switch technology and perform a final RF-FPGA demonstration. - Implement transition plans for a fully reconfigurable RF circuit technology at the component and system levels.			
Title: Nitride Electronic NeXt-Generation Technology (NEXT)	8.360	8.080	4.280
Description: To realize high performance analog, Radio Frequency (RF) and mixed-signal electronics, a next-generation transistor technology with high cutoff frequency and high breakdown voltage is under development. This technology will enable large voltage swing circuits for military applications that the current state-of-the-art silicon transistor technology cannot support. The objective of the Nitride Electronic neXt-generation Technology (NEXT) program is to develop a revolutionary, wide band gap, nitride transistor technology that simultaneously provides extremely high-speed and high-voltage swing [Johnson Figure of Merit (JFoM) larger than 5 Terahertz (THz)-V] in a process consistent with large scale integration of enhancement/depletion (E/D) mode logic circuits of 1000 or more transistors. In addition, this fabrication process will be reproducible, high-yield, high-uniformity, and highly reliable. The accomplishment of this goal will be validated through the demonstration of specific program Process Control Monitor (PCM) Test Circuits such as 5, 51 and 501-stage ring oscillators in each program phase. The impact of this next-generation nitride electronic technology will be the speed, linearity, and power efficiency improvement of RF and mixed-signal electronic circuits used in military communications, electronic warfare and sensing. ***FY 2013 Accomplishments:*** - Demonstrated world record, wide-bandgap nitride transistor technology with operation up to 450 GigaHertz (GHz) through scaling efforts for self-aligned structures with short gate length, novel barrier layers, and reduced parasitic elements. - Increased the Technology Readiness Level (TRL) of the transistor fabrication process for future power switching and Monolithic Microwave Integrated Circuit (MMIC) capability using advanced wide band gap devices. - Continued to improve the versatility and circuit design potential of the NEXT MMIC process by successfully integrating Schottky diodes. ***FY 2014 Plans:*** - Complete enhancement / depletion mode transistor scaling development for fully self-aligned nitride transistors with full process compatibility. - Develop NEXT process development kit for circuit designers. - Design and fabricate RF or mixed signal demonstration circuits based on latest NEXT transistors and integration processes. ***FY 2015 Plans:*** - Establish the baseline of the high-speed / high breakdown voltage NEXT fabrication technology with high reproducibility and yield.			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Design, fabricate, and test military-relevant circuits, such as RF power amplifiers, using the developed NEXT transistor technology. - Complete NEXT process design kit to allow external circuit designers to utilize NEXT technology in other advanced circuit designs.			
Title: Diverse & Accessible Heterogeneous Integration (DAHI)	27.153	34.385	33.400

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, the Compound Semiconductor Materials On Silicon (COSMOS) program enabled transistors of Indium Phosphide (InP) to be freely mixed with silicon complementary metal-oxide semiconductor (CMOS) circuits to obtain the benefits of both technologies (very high speed and very high circuit complexity/density, respectively). The Diverse & Accessible Heterogeneous Integration (DAHI) effort will take this capability to the next level, ultimately offering the seamless co-integration of a variety of semiconductor devices (for example, Gallium Nitride, Indium Phosphide, Gallium Arsenide, Antimonide Based Compound Semiconductors), microelectromechanical (MEMS) sensors and actuators, photonic devices (e.g., lasers, photo-detectors) and thermal management structures. This capability will revolutionize our ability to build true "systems on a chip" (SoCs) and allow dramatic size, weight and volume reductions for a wide array of system applications.

In the Applied Research part of this program, high performance RF/optoelectronic/mixed-signal systems-on-a-chip (SoC) for specific DoD transition applications will be developed as a demonstration of the DAHI technology. To provide maximum benefit to the DoD, these processes will be transferred to a manufacturing flow and made available (with appropriate computer aided design support) to a wide variety of DoD laboratory, Federally Funded Research and Development Center (FFRDC), academic and industrial designers. Manufacturing yield and reliability of the DAHI technologies will be characterized and enhanced. This program has basic research efforts funded in PE 0601101E, Project ES-01, and advanced technology development efforts funded in PE 0603739E, Project MT-15.

FY 2013 Accomplishments:
- Continued fabrication and testing of higher complexity new generation of heterogeneously-integrated wideband, ultra-high-linearity analog-to-digital converters with in situ silicon-enabled calibration and linearization.
- Demonstrated ultra-wideband Analog-to-Digital Converter (ADC) with signal-to-noise-and-distortion ratio (SINAD) of over 30 Decibels (dB) at input frequencies of up to 20GHz with instantaneous bandwidth of 6GHz.
- Completed final multi-project wafer run of multi-user two-technology compound-semiconductor-on-silicon foundry process.
- Demonstrated a wide array of RF/mixed-signal components utilizing heterogeneous integration, including low-noise amplifiers, high-speed track-and-hold circuits, RF digital-to-analog converters, and tunable bandpass filters, which demonstrate the advantages of heterogeneous integration over single-technology integrated circuits.

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated new CMOS-compatible processes to achieve heterogeneous integration with multiple diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices, including interconnect and thermal management approaches. - Initiated manufacturing, yield and reliability enhancement for multi-user foundry capability based on developed diverse heterogeneous integration processes. - Continued design and fabrication of high-complexity heterogeneously integrated RF/optoelectronic/mixed signal and circuits, such as wide band RF transmitters, advanced mixed-signal integrated systems, optoelectronic RF signal sources, and laser-radar chips. ***FY 2014 Plans:*** - Continue to develop new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices, including interconnect and thermal management approaches. - Continue manufacturing, yield and reliability enhancement for multi-user foundry capability based on developed diverse heterogeneous integration processes. - Continue design and fabrication of high complexity heterogeneously integrated RF/optoelectronic/mixed signal and circuits, such as wide band RF transmitters, advanced mixed signal integrated systems, optoelectronic RF signal sources, and laser-radar systems. ***FY 2015 Plans:*** - Complete development of new CMOS-compatible processes to achieve heterogeneous integration with diverse types of compound semiconductor transistors, MEMS, and non-silicon photonic devices, including interconnect and thermal management approaches. - Complete manufacturing, yield and reliability enhancement for multi-user foundry capability based on developed diverse heterogeneous integration processes. - Complete design and fabrication of high complexity heterogeneously integrated RF/optoelectronic/mixed signal and circuits, such as wide band RF transmitters, advanced mixed signal integrated systems, optoelectronic RF signal sources, and laser radar systems.			
Title: Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)	18.201	23.396	15.000
Description: The Micro-Technology for Position, Navigation, and Timing (micro-PNT) program is developing low-size, weight, power, and cost (SWaP+C) inertial sensors and timing sources. This suite of sensors, when integrated into an inertial measurement unit (IMU), will enable self-contained navigation and timing in the absence of signals from the Global Positioning System (GPS), due to environmental interference or adversary action such as GPS jamming. The micro-PNT program is developing miniature high performance gyroscopes, accelerometers, and clocks, based on both solid state and			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
atomic technologies. Advanced micro-fabrication techniques under development will enable the fabrication of a single package containing all the necessary devices in a volume the size of a sugar cube. Co-location of atomic physics and MEMS-based devices opens the possibility for utilization of combinatorial algorithms to enable fast start-up time and increased bandwidth of MEMS with the long-term stability and accuracy of MEMS sensors, thus effectively providing very accurate navigation devices in highly dynamic environments. The small SWaP+C of these technologies will enable ubiquitous guidance and navigation on all platforms, including guided munitions, unmanned aerial vehicles (UAVs), and individual soldiers. The successful realization of micro-PNT depends on the development of new microfabrication processes and novel material systems for fundamentally different sensing modalities, understanding of the error sources at the micro-scale, and understanding of scaling relationships for the size-reduction of sensors based on atomic physics techniques. The micro-PNT program includes research into novel techniques for fabrication and integration of three-dimensional MEMS devices as well as theoretical and experimental studies of new MEMS architectures and geometries for inertial sensing. Atomic physics research includes the development of new geometries and architectures for atomic inertial sensing and the development of techniques for improving the sensitivity and accuracy of miniaturized devices. Advanced research for the program is budgeted in PE 0603739E, Project MT-12. ***FY 2013 Accomplishments:*** - Developed architecture for co-integrated clock, accelerometers, and gyroscope on a single chip with a volume of less than ten cubic millimeters. - Demonstrated algorithmic techniques for on-chip error correction of an inertial sensor (improving bias stability to 100 parts-per million (ppm)). - Demonstrated fabrication and functionality of an integrated calibration micro-stage. - Explored and developed predictive models of error sources for gyroscope and accelerometers. - Identified physical and algorithmic self-calibration techniques to compensate for stability and drift of inertial sensors, effective to 100 (ppm) scale factor and bias stability. - Developed design space for chip-scale, atomic navigation sensor. - Developed hemispherical shell micro-resonators from novel materials (diamond, nickel alloy). - Developed new fabrication processes for improved packaging and narrow electrode gap alignment. ***FY 2014 Plans:*** - Demonstrate a prototype miniature inertial sensor based on atomic physics. - Demonstrate laboratory functionality of a MEMS-based IMU with a volume of less than 10mm^3. - Use predictive error models of gyroscopes and accelerometers to achieve better than 10ppm long term stability of scale factor and bias.			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate low damping of 3D hemispherical micro-gyroscopes, capable of operating with a high dynamic range in whole angle mode. - Demonstrate on-chip calibration with co-fabricated characterization stages. - Demonstrate improved functionality of Disc Resonant Gyroscope (DRG) with integrated quartz crystal oscillator. ***FY 2015 Plans:*** - Demonstrate on-chip calibration stages to track bias and scale factor stability repeatable to <100ppm. - Demonstrate a 10mm^3 silica IMU. - Demonstrate a miniaturized, low-drift Nuclear Magnetic Resonance (NMR) gyroscope. - Demonstrate a micro-hemispherical resonant gyroscope, operating in both whole-angle mode and rate mode.			
Title: Microscale Plasma Devices (MPD)	6.138	6.300	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 MPD applied research program is focused on transferring the fundamental scientific advances funded by PE 0601101E, Project ES-01 to produce complex circuit designs that may be integrated with commercial electronic devices. It is expected that the MPD program will result in the design and modeling tools, as well as the fabrication capabilities necessary to commercially manufacture high-performance microscale-plasma-device-based electronic systems for advanced DoD applications. ***FY 2013 Accomplishments:*** - Verified initial microplasma modeling simulation results against microscale plasma device measurement results to begin optimization of the microplasma modeling-and-simulation design tool (MSDT) for commercial development of microplasma-based electronics. - Investigated the use of microscale plasma devices for protection of sensor systems in extreme environments.			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Completed initial field testing of an MPD-based material for high power electromagnetic applications. ***FY 2014 Plans:*** - Continue integration of multiple simulation efforts into the modeling-and-simulation design tool (MSDT) for commercial development of microplasma based electronics and DoD systems. - Optimize plasma microcavity materials for DoD systems of interest, demonstrating robustness in high power electromagnetic environments. - Demonstrate and test nonlinear signal processing circuit concepts and architectures based on MPD technologies. ***FY 2015 Plans:*** - Complete integration of the simulation efforts into the MSDT for commercial development of microplasma based electronics. - Complete final testing of microcavity materials for robustness in a high power electromagnetic application. - Complete demonstration of plasma-based materials and devices for transition to DoD customers.			
Title: IntraChip Enhanced Cooling (ICECool)	11.000	21.500	20.000
Description: The IntraChip Enhanced Cooling (ICECool) program is exploring disruptive technologies that will remove thermal barriers to the operation of military electronic systems, while significantly reducing size, weight, and power consumption. These thermal barriers will be removed by integrating thermal management into the chip, substrate, or package technology. Successful completion of this program will raise chip heat removal rates to above 1 kilowatt/cm^2 and chip package heat removal density to above 1kW/cm^3 in RF arrays and embedded computers. Specific areas of focus in this program include overcoming limiting evaporative and diffusive thermal transport mechanisms at the micro/nano scale to provide an order-of-magnitude increase in on-chip heat flux and heat removal density, determining the feasibility of exploiting these mechanisms for intrachip thermal management, characterizing the performance limits and physics-of-failure of high heat density, intrachip cooling technologies, and integrating chip-level thermal management techniques into prototype high power electronics in RF arrays and embedded computing systems. ***FY 2013 Accomplishments:*** - Determined feasibility of implementing advanced thermal management techniques into compact defense electronic systems. - Determined limits of advanced thermal technologies through fundamental studies on intra and interchip cooling. - Initiated efforts to apply intra and interchip cooling as part of the thermal management approach of defense electronic systems. ***FY 2014 Plans:*** - Prepare and refine initial thermal models of intrachip cooling to explain and predict experimental results. - Demonstrate proof of concept of fundamental building blocks of evaporative intrachip/interchip thermal management including microfabrication in relevant electronic substrates and preliminary thermofluid results.			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate application-oriented thermal test vehicles to demonstrate the thermal benefits of embedded microfluidic cooling and model the anticipated electrical performance based on these thermal results. ***FY 2015 Plans:*** - Demonstrate the full implementation of the fundamental building blocks of evaporative intrachip/interchip cooling in relevant thermal test vehicles. - Demonstrate application-oriented electrical test vehicles to demonstrate the performance benefits of embedded microfluidic cooling and relate these results to system-level performance and size, weight, power and cost (SWaPC) through the use of intrachip thermal management technologies.			
Title: In vivo Nanoplatforms (IVN)	8.500	23.338	16.500
Description: The In vivo Nanoplatforms (IVN) program seeks to develop the nanoscale systems necessary for in vivo sensing and physiologic monitoring and delivery vehicles for targeted biological therapeutics against chemical and biological (chem-bio) threat agents. The nanoscale components to be developed will enable continuous in vivo monitoring of both small (e.g. glucose, lactate, and urea) and large molecules (e.g. biological threat agents). A reprogrammable therapeutic platform will enable tailored therapeutic delivery to specific areas of the body (e.g. cells, tissue, compartments) in response to traditional, emergent, and engineered threats. The key challenges to developing these systems include safety, toxicity, biocompatibility, sensitivity, response, and targeted delivery. The IVN program will have diagnostic and therapeutic goals that enable a versatile, rapidly adaptable system to provide operational support to the warfighter in any location. ***FY 2013 Accomplishments:*** - Achieved a safe in vivo nanoplatform sensor to detect one military-relevant analyte (e.g. glucose, nucleic acids) in living cells and/or tissue with a robust signal for greater than one month. - Achieved a safe and effective in vivo nanoplatform therapeutic to reduce a military-relevant pathogen or disease cofactor in living cells by at least 50%. - Facilitated development of a regulatory approval pathway for diagnostic and therapeutic nanoplatforms. ***FY 2014 Plans:*** - Achieve a safe in vivo nanoplatform sensor to detect two military-relevant analytes (e.g. glucose, nucleic acids) in a small animal with a robust signal for at least six months. - Achieve a safe and effective in vivo nanoplatform therapeutic to reduce a military-relevant pathogen or disease cofactor in a small animal by at least 70%. - Update regulatory approval pathway of identified safe and effective diagnostic and therapeutic nanoplatforms. ***FY 2015 Plans:***			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Achieve a safe in vivo nanoplatform sensor to detect five military-relevant analytes (e.g. glucose, nucleic acids) in a large animal with a robust signal for at least twelve months. - Achieve a safe and effective in vivo nanoplatform therapeutic to reduce a military-relevant pathogen or disease cofactor in a large animal by at least 90%. - Update regulatory approval pathway with results from safety and efficacy testing.			
Title: Pixel Network (PIXNET) for Dynamic Visualization	14.000	23.700	17.500

Description: The PIXNET program addresses the squad level capability gap for target detection, recognition and identification in all-weather and day/night missions. The vision of the program is to offer the warfighter a small and versatile infrared (IR) camera that would be affordable for individual soldiers and provide multiple IR band imagery with fusion capability to take full advantage of different wavelength-band phenomenology in a compact single unit. In the future, the availability of the PIXNET camera would enable a peer-to-peer networked system for image sharing within a squad, thereby providing a better common operating picture of the battlefield and significantly enhancing the warfighter's situational understanding. The program aims to develop a low size, weight and power (SWaP), low cost, soldier-portable multiband infrared camera that will provide real-time single and multiple band imagery using thermal and reflected-illumination bands. The camera will also provide fused reflective and thermal band imagery on demand. The use of fused imagery in the PIXNET design will allow the soldier to detect camouflaged targets and distinguish targets from decoys. The PIXNET camera will eliminate limitations posed by current capability, allowing detection, recognition and identification of targets whether in daylight or no-light conditions.

The PIXNET program will focus on a significant reduction in SWaP and cost of infrared sensor components to enable portability and ability to deploy widely to all participants in the theater. The emphasis on a small form will naturally enable new opportunities such as surveillance with small Unmanned Aerial Vehicles (UAV)s, rifle sights with multiple bands, and vehicle-mounted, helmet-mounted and handheld surveillance systems. The phenomenology of different infrared wavelengths will be exploited. The combination of a smart phone and PIXNET camera at the soldier level will enable more effective tactics, techniques and procedures (TTP) over the current capability. The PIXNET program takes advantage of the computing capability of smart phones to process and fuse multicolor images and send them as videos or still images to the warfighter's helmet-mounted display via a wireless or wired connection. PIXNET capability could be further exploited to enable a fully networked system, such as the Nett Warrior integrated multiple soldier systems capability, with multi-spectral still image and video sharing.

FY 2013 Accomplishments:
- Conducted multicolor fusion tests using separate video imagery in visible, shortwave and longwave to determine phenomenological advantages.
- Identified several Key Performance Parameters (KPPs) for the brass board design of the PIXNET camera.

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Evaluated four of the KPPs critical to the camera performance: range to identify target, power consumption, weight of hardware, and detector array format. - Completed trade study space and started work in preparation for the System Requirements Review (SRR) for the PIXNET Camera. ***FY 2014 Plans:*** - Develop and review IR camera design and overall architecture that will demonstrate digital image data transmission and signal processing via wireless connectivity using an android based platform. - Identify parameters required for multicolor helmet-mounted technology for very low SWaP multi-color IR camera. - Complete short wave (SW)/mid-wave (MW) optics design for clip-on weapon sight. - Identify wireless interface protocols for rifles/weapons and helmet displays that are compliant with dismount requirements. - Perform final design of the long-wave IR/very-near IR (LWIR/VNIR) camera cores, optic lens assemblies, display module, image fusion network power components, helmet package, image processing pipeline, and embedded software applications. - Demonstration of brass board components for the LWIR/VNIR helmet camera. ***FY 2015 Plans:*** - Refine algorithms to fuse data from thermal and reflective bands with good image registration. - Complete interim small form-factor camera integration and demonstrate connectivity to heads-up display and Android-based platform. - Readout Integrated Circuit (ROIC) tapeout and SW/MW fabrication. - Complete fabrication of LWIR/VNIR and start final integration of helmet camera. - Demonstrate multicolor image acquisition by interim PIXNET camera, data transmission to Android platform, image fusion by Android platform, and viewing of fused imagery on heads-up display.			
Title: Arrays at Commercial Timescales (ACT) ***Description:*** Phased arrays are critical system components for high performance military electronics with widespread applications in communications, electronic warfare and radar. The DoD relies heavily on phased arrays to maintain technological superiority in nearly every theater of conflict. The DoD cannot update these high cost specialized arrays at the pace necessary to effectively counter adversarial threats under development using commercial-of-the-shelf components that can undergo technology refresh far more frequently. The Arrays at Commercial Timescales (ACT) program will develop adaptive and standardized digital-at-every-element arrays. The hand designed, static analog beamformers will be replaced with cost effective digital array systems capable of a yearly technology refresh. By doing so, phased arrays will become ubiquitous throughout the DoD, moving onto many platforms for which phased arrays had been previously prohibitively expensive to develop or maintain. The basic research component of this program is budgeted under PE 0601101E, Project ES-01.	-	23.856	25.000

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2014 Plans: - Initiate development of common hardware components for phased-array elements that can be seamlessly integrated into a wide range of platforms and implement the first iteration of the common components in a state-of-the-art fabrication process. - Initiate the development of digital array systems with performance capabilities that evolve with Moore's law at commercial time scales. - Initiate the development of electromagnetic (EM) interface elements capable of reconfiguring for various array use cases and operational specifications. - Demonstrate reconfigurability of EM interface components for various array performance specifications and demonstrate compatibility with common digital back-end. - Identify government application spaces and transition paths that will make use of ACT common modules and reconfigurable antenna apertures. ***FY 2015 Plans:*** - Continue development of common hardware components for phased-array elements that can be seamlessly integrated into a wide range of platforms and implement the second iteration of the common components in a state-of-the-art fabrication process and test functionality in a laboratory environment. - Demonstrate Common Module hardware viability through government testing of delivered hardware components in a government furnished system platform. - Continue the development of EM interface elements capable of reconfiguring for various array use cases and operational specifications, and demonstrate tuning over an octave of bandwidth and over multiple polarization settings. - Continue to demonstrate reconfigurability of EM interface components for various array performance specifications, and demonstrate compatibility with common digital back-end. - Continue to identify government application spaces and transition paths for the ACT Common Module and reconfigurable antenna apertures.			
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 IR cameras. The sensitivity of an IR focal-plane array (FPA) is improved by cooling its detectors to cryogenic temperatures. The disadvantages of state-of-the-art Stirling cryo-coolers used for high performance IR FPAs are large size, high power and high cost. On the other hand, thermoelectric (TE) coolers used in low performance IR cameras are relatively small, high power, and it is difficult to achieve temperatures below 200 Kelvin (K). 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 MEMS technology, for making IR FPA coolers with very low SWaP-C. MEMS microfluidics,	-	5.000	1.500

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
piezoelectric MEMS, and complementary metal-oxide semiconductor (CMOS) electronics will be used to demonstrate an integrated cold head and compressor, all in a semiconductor chip. Since a J-T cooler works by cooling from gas expansion, the coefficient of performance is expected to be much higher than state-of-the-art TE coolers, while being significantly smaller than Stirling coolers. The chip-scale J-T cooler will be designed for pressure ratios of 4 or 5 to 1 with high compressor frequency in a small volume. The goal of the MC-FPA program will be to demonstrate cooling down to 150 K. The chip-scale micro-coolers will cost less and will be significantly smaller than current Stirling coolers. Once the proof-of-principle is demonstrated, the subsequent program effort will focus on transitioning to chip-scale manufacture on 8-12 inch wafers, resulting in cooler costs decreasing to as low as $50. An extended wavelength-range short-wave IR detector will be integrated with a micro-cooler for demonstration of the MC-FPA. The basic research component of this program is budgeted under PE 0601101E, Project ES-01. ***FY 2014 Plans:*** - Develop detector design for response in 1-2.4 microns. - Perform materials growth and characterization for detector fabrication. - Process Cadmium Zinc Telluride (CdZnTe) substrates for epitaxy. - Complete initial analysis to determine input cell design for readout integrated circuit (ROIC). - Fabricate and test a single stage MC-FPA. - Develop 640X480 extended shortwave infrared (1-2.4 micrometer cutoff) FPA. - Design a readout integrated circuit (ROIC) for the IR FPA chip. - Demonstrate camera electronics for the FPA with provision for chip-scale micro-cooler. ***FY 2015 Plans:*** - Fabricate 3-stage J-T micro-cooler. - Hybridize FPA to ROIC and integrate 3-stage J-T micro-cooler with complete backend packaging. - Complete camera integration & housing. - Complete camera tests and demo.			
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	-	9.645	5.500

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
technology for the DoD and Nation. The technological capability developed through VAPR will be demonstrated through a final test vehicle of a transient beacon. Basic research for the VAPR program is being performed in PE 0601101E, Project TRS-01. To manufacture transient systems at scale will require significant research and development into: higher levels of circuit integration and complexity to realize advanced circuit functionalities; integrated system designs to achieve required function (in modes that offer programmed or triggered transience); integration of novel materials into circuit fabrication processes; and development of new packaging strategies. The efficacy of the technological capability developed through VAPR will be demonstrated through a final test vehicle of a transient sensor system. The goal is to develop a suite of design principles, develop strategies and pathways, process flows, tools and basic components that are readily generalizable and can be leveraged towards the development of many other transient electronics devices. ***FY 2014 Plans:*** - Begin developing foundry fabrication of transient electronics with key functions (RF, memory, digital logic, power supply, etc.). - Begin developing increased circuit integration and complexity to implement advanced functionalities. - Initiate transient sensors and power supply strategy development. - Begin developing transient device fabrication approaches. - Initiate transience mode demonstration in test vehicles. ***FY 2015 Plans:*** - Achieve a transience time of less than or equal to 5 minutes for simple electronic devices. - Reduce the variability of transience time to less than or equal to 90 seconds for simple electronic devices. - Demonstrate capability to have reliable operation of simple transient electronic devices for greater than 24 hours after deployment, with subsequent controlled transience.			
Title: Gargoyle ***Description:*** Sensors, processors and users transmit data on a massive scale; however processing capabilities cannot keep pace. The result is missed warnings and delayed reaction. Digital electronics, while indispensable, cannot scale with the unprecedented demand for high-throughput processing. For example, aggregate communications through optical fibers are currently >100 Terabit/sec (Tbps) worldwide and are expected to exceed 1 Petabit/sec by 2020. In these high-rate optical links, signatures of malware propagation or denial of service attacks become small needles in a very large haystack. Conventional digital processing attempts to extract relevant information, but it is not nearly fast enough to keep up, and falls far short of 100% aperture capture. Gargoyle will develop photonic correlators for critical data processing tasks to provide near-zero latency, high-throughput processing of both digital and analog data. Advanced optical correlator technology has the potential to scale up with ever-	-	-	2.000

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
increasing bit rates. Applications for this technology include direct sequence spread spectrum bandwidths exceeding 10 Gigahertz (GHz), and cyber defense in fiber-optic networks with scalability to future transmission rates exceeding 10 Tbps. ***FY 2015 Plans:*** - Simulate photonic components for fundamental data-processing tasks, such as high-rate Fourier and Hilbert transforms, and cross-correlation. - Simulate, design and test processing pipelines for dispreading of Direct Sequence Spread Spectrum (DSSS) RF communications. - Design a broadband wireless communication DSSS link consisting of transmitter and receiver with spreading/dispreading factors exceeding 1,000.			
Title: Cold-Atom Microsystems (CAMS)	-	-	4.000
Description: Precision measurements based on atomic physics principles are the underlying technology of the most accurate measurement devices in the world, including practical devices such as atomic clocks and inertial sensors, as well as laboratory tests of fundamental physics. The field of atomic physics was revolutionized in the 1980's with the development of the technique of laser cooling of atoms. Utilizing precisely tuned lasers with high spectral purity (narrow linewidth), atoms may be cooled down to nearly absolute zero temperature. So-called cold atoms are of great practical value to DoD position, navigation, and timing (PNT) systems, for two reasons. First, because the atoms are nearly unmoving, it is possible to make relatively long-duration measurements of their internal state, with minimal collisions between atoms or between atoms and the walls of the containing vessel. This has led to the development of high-performance laboratory-based cold-atom fountain clocks, such as the U.S. national time standard, NIST-F1, and the rubidium fountains that underpin the U. S. Naval Observatory master clock. Secondly, taking advantage of the relatively slow velocities of cold atoms, atomic interferometers have been demonstrated, which provide the highest precision measurements of rotation and acceleration. Under the DARPA micro-PNT program, miniature high-performance cold atom-based atomic clocks, gyroscopes, and accelerometers are being developed and have demonstrated superior performance in relatively low size, weight, and power (SWaP). The Cold-Atom Microsystems (CAMS) program will develop enabling component technologies to support the practical deployment of cold-atom based microsystems, including low-SWaP atomic clocks, gyroscopes, and accelerometers. Technologies under investigation include high-efficiency narrow-linewidth laser sources, high-efficiency optical modulators, miniature high-isolation optical switches, compact low-loss optical isolators, miniature systems for laser frequency locking and agile frequency control, miniature ultra-high vacuum chambers and vacuum pumps, and techniques for controlling the vapor pressure of alkali metal atomic species over the DoD operating temperature range. ***FY 2015 Plans:***			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate miniature low-loss optical isolators. - Develop novel high-efficiency narrow-linewidth laser architectures. - Demonstrate alkali vapor pressure control over the DoD operating temperature range. - Develop and test of microscale high isolation (> 80 dB) optical shutters. - Develop microscale vacuum pumps capable of sustaining vacuum pressure of 1e-8 Torr.			
Title: Direct SAMpling Digital ReceivER (DISARMER)	-	2.000	2.000
Description: The goal of the Direct SAMpling Digital ReceivER (DISARMER) program is to produce a hybrid photonic-electronic analog-to-digital converter (ADC) capable of directly sampling the entire X-band (8-12 Gigahertz (GHz)). Conventional electronic wideband receivers are limited in dynamic range by both the electronic mixer and the back-end digitizers. By employing an ultra-stable optical clock, the DISARMER program will allow for mixer-less digitization and thereby improve the dynamic range 100x over the state of the art. Such a wide bandwidth, high fidelity receiver will have applications in electronic warfare and signals intelligence systems while dramatically reducing the cost, size and weight of these systems. The DISARMER program will develop a low jitter mode-locked laser to be used as the sampling source. The program will also develop a novel photonic processor chip on a silicon platform capable of hybrid electronic-photonic track-and-hold functionality and coherent photo-detection. These silicon photonic integrated circuits will be integrated with CMOS driver circuits and packaged for integration in the full DISARMER system. This program has advanced technology development efforts funded in PE 0603739E, Project MT-15. ***FY 2014 Plans:*** - Complete preliminary design of photonic processor chip. - Complete preliminary design of low jitter mode-locked laser with 8 GHz repetition rate. ***FY 2015 Plans:*** - Complete architecture evaluation to determine the best mix of electronics and photonics for optimized performance and power consumption. - Fabricate and test the building blocks of the photonic processor. - Package photonic processor chip and electronic integrated circuit chip. - Demonstrate and test mode locked laser with 8 GHz repetition rate, 1 ps pulse width, and 5 fs of integrated timing jitter.			
Title: Fast and Big Mixed-Signal Designs (FAB)	-	-	4.000
Description: Developing capabilities to intermix and tightly integrate silicon processes which are currently supported at different scaling nodes and by different vendors is critical to increasing the capabilities of high-performance military microelectronics. Specifically, silicon-germanium (SiGe) processes allow complementary metal-oxide semiconductor (CMOS) logic to be integrated			

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
with RF heterojunction bipolar transistors (HBTs), which enables mixed-signal circuits having RF analog capabilities tightly coupled to digital processing. The Fast and Big Mixed-Signal Designs (FAB) program proposes to engage with a semiconductor fabrication partner to develop a SiGe fabrication process integrating 14nm CMOS. The SiGe technology will enable the development of faster, more precise RF and signal acquisition components, while the 14nm CMOS process will enable low-power digital circuitry that can provide the large throughput required for data from the analog components. The ability to mix massive digital computation at lower power with the fast sampling enabled by Silicone Germanium (SiGe) HBTs gives a powerful platform for future generations of Electronic Warfare (EW) systems. This program will seek to overcome the tradeoffs in providing the highest performance analog performance versus the densest and lowest power digital processes. Success will enable higher performance, lower cost, and more rapid insertion of advanced process technology into military electronics. ***FY 2015 Plans:*** - Determine the best choices for the RF and digital technologies and the best methods of co-integration (monolithic, through-silicon via (TSV)s, interposer, etc.) in order to achieve program objectives, along with identifying partner(s) for fabrication and/or integration. - Begin circuit design activities to determine performance benefits of new processes enabled by the program. - Study the best technology for various RF functional blocks for optimal use of mixed technologies.			
Title: Microscale Power Conversion (MPC) ***Description:*** Today's power amplifiers utilize large, bulky, independently designed fixed voltage power supplies that fundamentally limit Radio Frequency (RF) system output power, power efficiency and potential for integration. The Microscale Power Conversion (MPC) program is developing X-band RF transmitters as system-in-package modules, in which integrated circuit power amplifiers are integrated with dynamic, variable voltage power supplies using high-speed power switches. Such an integrated microsystem will support military applications requiring several hundred Megahertz (MHz) of RF envelope bandwidth at large peak-to-average power ratios. This integration approach will realize RF systems with significantly higher overall power efficiency and waveform diversity by changing from a fixed power supply architecture to a dynamic power supply architecture. The program is structured in two technical tracks. The first track is developing high-speed power switch technology to be used in the design of dynamic power supply and modulator circuits. The second track is developing the simultaneous co-design and integration of the RF power amplifier and dynamic power supply circuits to achieve maximum overall power efficiency for the desired waveforms of interest. The impact of this program will be the increased deployment of MPC RF transmitter systems on DoD platforms due to their more compact size, high efficiency, lower lifecycle cost and enhanced RF performance enabling, for example, significantly communications rates. ***FY 2013 Accomplishments:***	8.561	8.800	-

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Continued development of very high frequency, low-loss power switch technology for implementing large envelope-bandwidth modulators for RF power amplifiers. - Initiated co-designs of advanced X-band power amplifier technologies to include drain and gate bias modulation, dynamic output impedance matching, and closed-loop control. - Demonstrated second generation power supply modulator with high efficiency in a laboratory environment. - Designed and prototyped second generation transmitter architectures for highly efficient handling of large peak-to-average ratio RF waveforms for military systems. - Fabricated low-loss packages and monolithically integrated switches for amplifier-modulator circuits. ***FY 2014 Plans:*** - Complete very high frequency, low-loss power switch technology for implementing large envelope-bandwidth modulators for RF power amplifiers. - Demonstrate final co-designs of advanced X-band transmitter to include drain and gate bias modulation, dynamic output impedance matching, and closed-loop control with fast-switching power modulation. - Furnish power switch process design kits to DoD contractors for use in future power supply modulator or power amplifier designs. - Demonstrate RF transmission of relevant military waveforms for electronic warfare applications.			
Title: Photonically Optimized Embedded Microprocessor (POEM) ***Description:*** Based upon current scaling trends, microprocessor performance is projected to fall far short of future military needs. Microprocessor performance is saturating and leading to reduced computational efficiency because of the limitations of electrical communications. The POEM program will demonstrate chip-scale, silicon-photonic technologies that can be integrated within embedded microprocessors for seamless, energy-efficient, high-capacity communications within and between the microprocessor and dynamic random access memory (DRAM). This technology will propel microprocessors onto a higher performance trajectory by overcoming this "memory wall". ***FY 2013 Accomplishments:*** - Demonstrated a photonic link between two chips fabricated in a DRAM foundry consuming 2.8 picojoules (pJ/bit) including control and driver circuitry. - Continued to develop and improve complementary metal-oxide semiconductor (CMOS)-compatible modulator, multiplexer, coupler, and photodetector devices and associated drivers for low-power, high capacity photonic links for insertion in final demonstration. - Demonstrated a complete, integrated 8-channel photonic transmitter operating at 100 Gigabit/s and 330 femtojoules per bit (fJ/bit), and a complete, integrated, 8-channel photonic receiver operating at 80 Gb/s and 500 fJ/bit. - Developed an on-chip, uncooled, frequency-stabilized laser operating at ~7% wall plug efficiency.	15.000	1.500	-

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Identified applications where a cluster of photonically optimized microprocessors is useful and designed the cluster architecture, photonic network, and parallel algorithms for community analysis on large graphs. ***FY 2014 Plans:*** - Demonstrate a photonic link between a CMOS chip and a DRAM chip consuming low (few picojoule (pJ)) energy/bit employing foundry-compatible photonic devices and respective control and driver circuits. - Fabricate and test optical receiver circuits with 200 nanoseconds (ns) locking time and consuming 10 pJ/bit. - Design and test new algorithms that effectively parallelize graph analytic problems, taking advantage of the high bandwidth photonic interconnects. - Study and optimize the material stack for fabricating an on-chip, uncooled laser operating at 1550 nm and ~ 10% wall plug efficiency.			
Title: Advanced X-Ray Integrated Sources (AXIS) ***Description:*** The Advanced X-Ray Integrated Sources (AXIS) program developed tunable, mono-energetic, spatially coherent X-ray sources with greatly reduced size, weight and power while dramatically increasing their electrical efficiency through application of micro-scale engineering technologies such as MEMS and NEMS. Such X-ray sources enabled new versatile imaging modalities based on phase contrast techniques which are 1000X more sensitive than the conventional absorption contrast imaging. Such imaging modalities enabled 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 Applied Research component of this effort focused on applying basic research discoveries to the development of a compact, pulsed X-ray source. Such sources are a necessary component to enable future technologies with high-speed motion tomographic imaging capabilities and the design verification of integrated circuits. This program also included related basic research efforts funded under PE 0601101E, Project ES-01. ***FY 2013 Accomplishments:*** - Fabricated and demonstrated a short-lifetime photoconductor switched tip-on-post (Spindt) field emitter with short pulse duration, high pulse repetition rate, and low emittance. - Began fabrication of an advanced hard X-ray source based on a whispering gallery mode resonator with multi-layer reflectivity for confinement and gain. - Coordinated the development of devices capable of producing synchrotron-quality X-rays by integrating the most successful components (cathodes, accelerators, undulators & lasers) in the program.	8.000	-	-

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Obtained X-ray images from an array of micro-focused X-ray sources fabricated for the AXiS program.			
Title: Quantum Information Science (QIS) ***Description:*** The Quantum Information Science (QIS) program explored all facets of the research necessary to create new technologies based on quantum information science. Research in this area has the ultimate goal of demonstrating the potentially significant advantages of uniquely quantum effects in communication and computing. The QIS program addressed the fundamental material science and physics associated with uniquely quantum effects in materials. The primary technical challenges include loss of information due to quantum decoherence and the practical limitations associated with operation temperatures, susceptibility to electronic and magnetic noise, coupling between quantum devices, etc. Theoretical efforts in QIS investigated novel techniques for preserving coherence, distributing quantum entanglement, and efficiently modeling quantum operations. Complementary experiments sought to demonstrate quantum devices with better coherence properties than existing devices and to implement entangling operations between two or more quantum devices. Future technologies utilizing quantum information science could enable ultra-secure communications; faster algorithms for optimization and simulation in logistics, war gaming, and pharmaceutical development; and new methods for image and signal processing in measurement and signature intelligence activities (MASINT). ***FY 2013 Accomplishments:*** - Improved speed and accuracy of numerical modeling of quantum device operation. - Developed design, growth, and fabrication techniques for enhancement-mode quantum devices with improved performance. - Demonstrated coupling of a spin qubit to a superconducting resonator for transport of quantum information over centimeter-scale distances.	1.138	-	-
Title: Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) ***Description:*** The vision of the Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) program was the development of biological-scale neuromorphic electronic systems for autonomous, unmanned, robotic systems where humans are currently the only viable option. Successful development of this technology could revolutionize warfare by providing intelligent terrestrial, underwater, and airborne systems that remove humans from dangerous environments and remove the limitations associated with today's remote-controlled robotic systems. Applications for neuromorphic electronics include not only robotic systems, but also natural human-machine interfaces and diverse sensory and information integration applications in the defense and civilian sectors. ***FY 2013 Accomplishments:*** - Fabricated neuromorphic chips of 1 million neurons performing behavioral tests in the virtual environment.	6.842	-	-

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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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrated functionality of chip performing perception challenge task and benchmark against state-of-the-art algorithms and methods. - Determined scalability of hardware systems and future densities and power consumption for next-generation systems.			
Title: Self-HEALing mixed-signal Integrated Circuits (HEALICs) ***Description:*** Virtually all DoD systems employ mixed-signal circuits for functions such as communications, radar, navigation, sensing, and high-speed image and video processing. A self-healing integrated circuit is defined as a design that is able to sense undesired circuit/system behaviors and correct them automatically. As semiconductor process technologies are being scaled to even smaller transistor dimensions, there is a dramatic increase in intra-wafer and intra-die process variations, which has a direct impact on yield and realized circuit performance, including significantly increased sensitivity to temperature and aging effects. The Self-HEALing mixed-signal Integrated Circuits (HEALICs) program developed technologies to autonomously maximize the number of fully operational mixed-signal systems-on-a-chip (SoC) per wafer that meet all performance goals in the presence of extreme process technology variations, and to sustain circuit performance in the field in the face of changing environmental conditions and component aging. This applied research program developed techniques to regain lost performance and stabilize operation of mixed-signal SoCs over system lifetimes. Consequently, the long-term reliability and performance of DoD electronic systems may be enhanced. ***FY 2013 Accomplishments:*** - Continued to integrate previously demonstrated mixed-signal circuit designs into full self-healing microsystems/SoCs and showed self-healing techniques capable of achieving >95% performance yield with <5% power consumption overhead. - Continued to develop global self-healing control at the microsystem/SoC level. - Demonstrated self-healing design strategies to compensate for chip aging. - Made design data for self-healing circuit library widely available for DoD user access.	1.940	-	-
Title: Efficient Linearized All-Silicon Transmitter ICs (ELASTx) ***Description:*** The Efficient Linearized All-Silicon Transmitter ICs (ELASTx) program developed revolutionary high-power/high-efficiency/high-linearity single-chip millimeter (mm)-wave transmitter integrated circuits (ICs) in leading-edge silicon technologies for future miniaturized communications and sensor systems on mobile platforms. The high levels of integration possible in silicon technologies enable on-chip linearization, complex waveform synthesis, and digital calibration and correction. Military applications include ultra-miniaturized transceivers for satellite communications-on-the-move, collision avoidance radars for micro-/nano-air vehicles, and ultra-miniature seekers for small munitions. The technology developed under this program was leveraged to improve the performance of high-power amplifiers based on other non-silicon technologies, through heterogeneous integration strategies. Significant technical obstacles were overcome including the development of highly efficient circuits for increasing	7.622	-	-

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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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
achievable output power of silicon devices (e.g., device stacking, power combining) at mm-waves; scaling high-efficiency amplifier classes to the mm-wave regime; integrated linearization architectures for complex modulated waveforms; and robust RF/mixed-signal isolation strategies. ***FY 2013 Accomplishments:*** - Demonstrated watt-level, high power-added efficiency (PAE) silicon-based PA circuits at W-band frequencies. - Demonstrated linearized transmitter circuits based on high-PAE power amplifiers (Pas) at W-band frequencies with complex modulated waveforms. - Demonstrated fully-integrated, watt-level, System-on-Chip transmitter at W-band frequencies with complex modulated waveforms. - Initiated development of watt-level, high PAE silicon-based PA circuits at D-band frequencies. - Initiated development of linearized transmitter circuits based on high PAE PAs at D-band frequencies with complex modulated waveforms.			
Title: Analog-to-Information (A-to-I) Look-Through ***Description:*** The Analog-to-Information (A-to-I) Look-Through program fundamentally improved the operational bandwidth, linearity, and efficiency of electronic systems where the objective is to receive and transmit information using electromagnetic (radio) waves under extreme size/weight/power and environmental conditions required for DoD applications. The A-to-I Look-Through program developed ultra-wideband digital radio frequency (RF) receivers based on Analog-to-Information Converter (AIC) technology. Compared to conventional RF receivers, AIC-based designs increased receiver dynamic range and frequency band of regard while reducing data glut, power consumption and size. Likewise, limitations of current-art power amplifier technology in simultaneously achieving high operational bandwidth, linearity, efficiency and power has resulted in well documented instances of electronic fratricide. This program overcomes these limitations by converting digital signals directly to high power RF analog signals, thus eliminating the traditional high power amplifiers that are limited by the above-mentioned tradeoffs. Transition is anticipated into airborne SIGINT and electronic warfare systems, as well as ground-based special operations forces systems. ***FY 2013 Accomplishments:*** - Finalized technology transition plans and transitioned A-to-I receivers to operationally-focused end user organizations. - Completed design, tape out, fabrication and characterization in laboratory environment of 16-tap Look-Through transmitters with high linearity, high power, wide bandwidth and high efficiency. - Demonstrated capability of transmitter cells and associated distributed architectures to be re-programmed to perform distributed receiver-mode functions in order to mitigate electronic fratricide.	2.800	-	-

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 0602716E / *ELECTRONICS TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrated the transmitter performance in representative environments for a DoD system of interest achieving a 60 dB performance. - Initiated design and tape out of final, large-scale Look-Through transmitters meeting the final program goals of high linearity, high power, wide bandwidth and high efficiency. - Initiated planning for laboratory testing of final, large-scale Look-Through transmitters, demonstrating the final transmitter performance in realistic environments for a DoD system of interest.			
Title: Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) ***Description:*** The Advanced Wide Field of View (FOV) Architectures for Image Reconstruction & Exploitation (AWARE) program addressed the passive imaging needs for multi-band, wide-field-of-view (FOV) and high-resolution imaging for ground and near-ground platforms. The AWARE program solved the technological barriers that will enable wide-FOV, high resolution and multi-band camera architectures by focusing on four major tasks: high space-bandwidth product (SBP) camera architecture; small-pitch-pixel focal plane array architecture; broadband focal plane array architecture; and multi-band focal plane array architecture. The AWARE program demonstrated technologies such as detectors, focal plane arrays, read-out integrated circuitry, and computational imaging that enable wide FOV and high space-bandwidth, novel optical designs, high resolution and multiple wavelength-band imagers. These technologies will be integrated into subsystem demonstrations under the related project in PE 0603739E, MT-15. ***FY 2013 Accomplishments:*** - Demonstrated a 2 gigapixel camera with greater than 100 degree FOV. - Continued development of a 10 gigapixel camera. - Completed AWARE-2 camera with glass microcameras and demonstrated 2-gigapixel video. AWARE-2 will have 38.4 milliradian (mrad) instantaneous (I)FOV, 100 degrees by 60 degrees FOV, 2 gigapixels, and entrance pupil 11.1 mm. - Completed AWARE-10 camera with 10-Gigapixel and 12.6 mrad IFOV. - Completed field tests for both cameras.	6.000	-	-
Accomplishments/Planned Programs Subtotals	192.349	233.469	179.203

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

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 0602716E / *ELECTRONICS TECHNOLOGY*

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE 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	-	168.376	144.804	129.723	-	129.723	178.043	186.011	189.790	193.755	-	-
AIR-01: *ADVANCED AEROSPACE SYSTEMS*	-	168.376	144.804	129.723	-	129.723	178.043	186.011	189.790	193.755	-	-

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

A. Mission Description and Budget Item Justification

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

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	174.316	149.804	184.227	-	184.227
Current President's Budget	168.376	144.804	129.723	-	129.723
Total Adjustments	-5.940	-5.000	-54.504	-	-54.504
• Congressional General Reductions	-0.240	-			
• Congressional Directed Reductions	-12.697	-5.000			
• Congressional Rescissions	-	-			
• Congressional Adds	7.500	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	4.254	-			
• SBIR/STTR Transfer	-4.757	-			
• TotalOtherAdjustments	-	-	-54.504	-	-54.504

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004, sequestration adjustments, the SBIR/STTR transfer offset by Congressional adds and reprogrammings.
FY 2014: Decrease reflects a reduction for prior year carryover.
FY 2015: Decrease reflects transition of LRASM work to the Services and drawdown of the Persistent Close Air Support program.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Persistent Close Air Support (PCAS)	22.792	26.304	16.723

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: The Persistent Close Air Support (PCAS) program will significantly increase close air support (CAS) capabilities by developing a system to allow continuous CAS availability and lethality to the supported ground commander. The enabling technologies are: manned/unmanned attack platforms, next generation graphical user interfaces, data links, digital guidance and control, and advanced munitions. PCAS will demonstrate the ability to digitally task a CAS platform from the ground to attack multiple/simultaneous targets. PCAS will allow the Joint Tactical Air Controller (JTAC) the ability to rapidly engage multiple moving targets simultaneously within the area of operation. PCAS's ability to digitally task a CAS platform to attack multiple/simultaneous targets would improve U.S. ground forces operations and speed of attack. The system will be designed to reduce collateral damage and potential fratricide to friendly forces. The anticipated transition partners are the Air Force, Special Operations Command, and the United States Marine Corps. ***FY 2013 Accomplishments:*** - Integrated subcomponent developer critical enabling technology components into system integrator A-10 and JTAC kit designs. - Performed field testing of Government furnished JTAC targeting software with the United States Marine Corps and Special Forces. - Designed modifications to A-10 demonstration aircraft and conducted software and hardware ground testing of avionics equipment. - Completed designs of next generation JTAC kit and performed hardware and software breadboard testing in a laboratory environment. - Commenced new technology development to benefit manned/unmanned aircraft conducting close air support, including a smart-rail device that will contain the elements necessary to execute PCAS capability across a variety of platforms. - Coordinated with flight testing entities and Government safety partners to ensure safety of flight of PCAS air technologies to include avionics and weapons engagement algorithms. ***FY 2014 Plans:*** - Perform ground test of A-10 demonstration aircraft architecture, networking, and avionics. - Conduct flight tests of PCAS aircraft equipped with LITENING targeting Pod with advanced datalink capabilities. - Complete hardware/software fabrication and field test of prototype PCAS kit for dismounted JTAC. - Conduct technical readiness review of PCAS aircraft systems and JTAC kit. - Prepare for and commence live fire demonstrations of PCAS prototype system. ***FY 2015 Plans:*** - Complete flight testing of PCAS prototype system. - Transition elements of PCAS air and ground systems to targeted Service partners.			
Title: Advanced Aerospace System Concepts	3.381	3.000	3.000

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: Studies conducted under this program examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact/improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future programs or refocus ongoing work. Topics of consideration include: methods of defeating enemy anti-aircraft attacks; munition technologies to increase precision, range, endurance, and lethality of weapons for a variety of mission sets; novel launch systems; air vehicle control, power, propulsion, materials, and architectures; and payload and cargo handling systems. ***FY 2013 Accomplishments:*** - Performed trade studies and modeling and simulation for novel technologies. - Conducted enabling technology and sub-system feasibility experiments. ***FY 2014 Plans:*** - Define performance constraints and determine design flexibility. - Validate sub-system performance and conduct sub-system risk reduction testing. ***FY 2015 Plans:*** - Conduct brassboard demonstrations of novel technologies. - Initiate studies of emerging concepts.			
Title: Tactically Exploited Reconnaissance Node (TERN)	12.185	16.000	32.000
Description: The goal of the Tactically Exploited Reconnaissance Node (TERN) program is to develop a systems approach for, and perform technical demonstration of, a Medium-Altitude, Long-Endurance Unmanned Aerial Vehicle (MALE UAV) capability from smaller ships. The program will demonstrate the technology for launch and recovery of large unmanned aircraft capable of providing persistent 24/7 Intelligence, Surveillance, and Reconnaissance (ISR) and strike capabilities at long radius orbits. By extending the ISR/strike radius and simultaneously increasing time on station beyond current capabilities from smaller ships, TERN will enable novel operational concepts including maritime surveillance and responsive, persistent deep overland ISR and strike, without requirement for forward basing. To achieve these goals, the program will create new concepts for aircraft launch and recovery, aircraft logistics and maintenance, and aircraft flight in regimes associated with maritime operating conditions. The program will culminate in a launch and recovery demonstration. Application of TERN technologies and operational concepts will enable a novel and cost efficient approach for multiple mission sets. The anticipated transition partner is the Navy. ***FY 2013 Accomplishments:*** - Initiated launch and recover technique evaluations and trade studies.			

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated studies on integration with existing Service systems and systems architectures. ***FY 2014 Plans:*** - Define the launch and recovery technique through evaluations and trade studies. - Complete studies on integration with existing Service systems and systems architectures. - Study aircraft design trades and approaches to best meet performance goals at minimum lifecycle cost. - Begin development of simulation and control schemes to achieve high precision approach. - Identify equipment and interface requirements for ship launch and recovery systems. ***FY 2015 Plans:*** - Continue technology maturation and preliminary design. - Initiate risk reduction simulations and testing. - Begin fabrication and testing of demonstrator system hardware.			
Title: Aerial Reconfigurable Embedded System (ARES)	-	23.000	23.000
Description: 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. In FY13, this program was funded from PE 0602702E, Project TT-07. The anticipated transition partners for this effort are the Army, Marine Corps, and Special Operations Forces. ***FY 2014 Plans:*** - Complete Critical Design Review for the ARES system. - Fabricate custom components, acquire powerplant and drivetrain components. - Perform one third scale powered tunnel test of flight module with cargo module. - Conduct component testing and static propulsion testing, showing feasibility and function of critical technology components.			

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete development of flight control software to ensure successful flight and ground testing. - Conduct subsystem testing and integration of components into the full scale prototype ARES system. - Complete hardware-in-the-loop and software-in-the-loop testing with fully integrated full scale prototype ARES system. - Conduct a test readiness review in preparation for ground and test demonstrations of the prototype vehicle. ***FY 2015 Plans:*** - Conduct ground demonstrations of the prototype vehicle. - Conduct flight test demonstrating that the prototype meets program objectives.			
Title: Hypersonic Air-breathing Weapon Concept (HAWC) ***Description:*** The objective of the Hypersonic Air-breathing Weapon Concept (HAWC) program, an outgrowth of the Integrated Hypersonics program, is to develop and demonstrate technologies that will enable transformational changes in responsive, long-range strike against time-critical or heavily defended targets. HAWC will pursue flight demonstration of the critical technologies for an effective and affordable air-launched hypersonic cruise missile. These technologies include advanced air vehicle configurations capable of efficient hypersonic flight, hydrocarbon scramjet-powered propulsion to enable sustained hypersonic cruise, thermal management approaches designed for high-temperature cruise, and affordable system designs and manufacturing approaches. HAWC technologies also extend to reusable hypersonic air platforms for applications such as global presence and space lift. The HAWC program will leverage advances made by the previously funded Falcon, X-51, and HyFly programs. This is a joint program with the Air Force, and HAWC technologies are planned for transition to the Air Force after flight testing is complete. ***FY 2014 Plans:*** - Conduct hypersonic air-breathing missile objective system trades studies and conceptual design definition. - Derive hypersonic air-breathing missile demonstration system design from the objective system and begin developing the suite of enabling technologies. - Begin developing flight testing plans for the hypersonic air-breathing missile demonstrator. - Initiate risk reduction testing of enabling subsystem technologies for the hypersonic air-breathing missile demonstrator. ***FY 2015 Plans:*** - Continue risk reduction testing of subsystem technologies for hypersonic air-breathing missile demonstrator. - Complete preliminary design of hypersonic air-breathing missile flight demonstration system. - Complete detailed plans for flight testing of the air-breathing missile demonstration system. - Begin procurement of long lead hardware for hypersonic air-breathing missile flight demonstration vehicle.	-	15.000	25.000
Title: Tactical Boost Glide	-	28.000	15.000

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: The Tactical Boost Glide (TBG) program, an outgrowth of the Integrated Hypersonics program, is a Joint DARPA / Air Force effort that will develop and demonstrate technologies to enable air-launched tactical range hypersonic boost glide systems, including a flight demonstration of a vehicle that is traceable to an operationally relevant weapon that can be launched from current platforms. The program will also consider traceability to, and ideally compatibility, with the Navy Vertical Launch System (VLS). The metrics associated with this objective include total range, time of flight, payload, accuracy, and impact velocity. The program will address the system and technology issues required to enable development of a hypersonic boost glide system considering (1) vehicle concepts possessing the required aerodynamic and aero-thermal performance, controllability and robustness for a wide operational envelope, (2) the system attributes and subsystems required to be both survivable and lethal in relevant operational environments, and (3) approaches to reducing cost and improving affordability for both the demonstration system and future operational systems. TBG capabilities are planned for transition to the Air Force and the Navy. ***FY 2014 Plans:*** - Complete trade space analysis for tactical range hypersonic boost glide systems. - Begin development of TBG Concept of Operations (ConOps). - Begin development of TBG Operational System (OS) conceptual designs and system capabilities. - Begin development of TBG Demonstration System (DS) conceptual design and system requirements. - Begin initial technology maturation plans (TMPs). ***FY 2015 Plans:*** - Complete TBG Operational System conceptual design reviews and system capability documentation. - Complete TBG Demonstration System conceptual design and systems requirements reviews. - Complete initial TMPs. - Select booster and launch platforms. - Conduct initial test range and range safety coordination. - Select TBG demonstration test range. - Complete Phase I aerodynamic and aerothermal concept testing. - Complete first generation aero databases. - Develop initial flight test plan.			
Title: Collaborative Operations in Denied Environment ***Description:*** The goal of the Collaborative Operations in Denied Environment (CODE) program is to enhance mission performance, reduce cost, confound adversaries, and reduce reliance on space assets for navigation and communication by distributing mission functions such as sensing, communication, precision navigation, kinetic, and non-kinetic effects to small platforms and increasing their level of autonomy. Collaboration of multiple assets offers new possibilities to conduct military	-	8.000	15.000

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
missions using smaller air platforms to enhance survivability, reduce overall acquisition cost, create new effects, increase communications range and robustness in denied environments, increase search area, increase areas held at risk, reduce target prosecution reaction time, and provide multi-mission capabilities by combinations of assets. This program is an outgrowth of the Manned-Unmanned Collaborative Autonomy program budgeted in PE 0602702E, TT-13. This 6.3 effort will specifically focus on developing and demonstrating approaches that will expand the mission capabilities of legacy air assets though autonomy and collaborative behaviors. ***FY 2014 Plans:*** - Initiate systems engineering phase. - Perform trade studies and decompose selected missions. - Develop collaborative algorithms, autonomous tactics, concepts for communication, and supervisory interface. - Develop software module specifications compliant with standard based open architecture including OSD umanned aircraft system Control Segment. - Evaluate algorithms, tactics, communication and interfaces, in high fidelity non-real time simulation against key performance parameters. ***FY 2015 Plans:*** - Implement algorithms in first release of flightworthy software (release 1) hosted in mission computer compatible with demonstration platform and objective operational platforms. - Modify demonstration platform to include mission computer and mesh network capable radio. - Demonstrate in-flight capabilities of release 1 focused on vehicle level autonomy, including on-board real time sensor processing, contingency management, complex flight path planning. - Demonstrate release 1 collaboration algorithms in real time simulation, including low bandwidth sensor fusion and collaborative tasking that maximizes system effectiveness. - Develop collaborative algorithms, tactics, concepts for communication, and human interface. - Evaluate algorithms, tactics, communication and interfaces, in non-real time simulation.			
Title: Next Generation Air Dominance Study ***Description:*** The Next Generation Air Dominance study will define the projected threat domains and capability gaps for the 2020-2050 timeframe. DARPA will conduct a study of current air dominance efforts in coordination with the United States Air Force and Navy and explore potential technology developmental areas to ensure the air superiority of the United States in the future. The study will consider roles of manned and unmanned platforms; the relative performance of alternative integrated systems concepts that combine various mixes of capabilities networked together; and the cost effectiveness of alternative balances of platforms and systems that provide surveillance, command and control, electronic warfare, and weapons functions. Innovative concepts for platform, propulsion, sensors, weapons integration, avionics, and active and passive survivability features	5.000	5.000	-

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
will be explored as part of the concept definition effort. This effort will also explore the expanded development and use of automated and advanced aerospace engineering design tools, modeling, and simulation in areas that can increase the likelihood of producing more capable products with improved efficiency. Following the initial multi-agency study, DARPA will present technical challenges to industry to allow them to explore and present potential solutions as part of the technical feasibility and system integration studies. Enabling technologies are advanced networking capabilities, reliable navigation, passive and active defense, electronic attack, area denial, advanced sensors, and cyber technologies. After the study, it is envisioned that high potential prototype programs will emerge to develop technologies for future air dominance. Early planning for future technologies will also help to define the funding baselines for DoD research and development and acquisition programs. ***FY 2013 Accomplishments:*** - Defined projected 2020-2050 threat domains and capability gaps. - Identified funded baselines for DoD efforts for R&D and acquisition. - Identified high value technologies and prototype opportunities. - Out-briefed senior leadership on threat picture and high value opportunities. - In-briefed industry and obtained feedback on potential technology opportunities. ***FY 2014 Plans:*** - Conduct technology feasibility and system integration studies of identified high value technologies. - Conduct Technical Interchange Meeting (TIM) to coordinate between development efforts. - Out-brief senior leadership on results of technology development efforts, with high-potential prototype programs recommendations.			
Title: Long Range Anti-Ship Missile Demonstration (LRASM) ***Description:*** In response to emerging threats, DARPA is building upon recent technology advances to develop and demonstrate standoff anti-ship strike technologies to reverse the significant and growing U.S. naval surface strike capability deficit. The Long Range Anti-Ship Missile (LRASM) program is investing in advanced component and integrated system technologies capable of providing a dramatic leap ahead in U.S. surface warfare capability focusing on organic wide area target discrimination in a network denied environment, innovative terminal survivability in the face of advanced defensive systems, and high assurance target lethality approaches. Specific technology development areas will include: robust precision guidance, navigation and control with GPS denial, multi-modal sensors for high probability target identification in dense shipping environments, and precision aimpoint targeting for maximum lethality. Component technologies are being developed, demonstrated, and integrated into a complete weapon system. The program will result in a high fidelity demonstration to support military utility assessment. LRASM is a joint DARPA/Navy effort. ***FY 2013 Accomplishments:***	59.005	20.500	-

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Conducted high fidelity independent government performance assessment of detailed designs against key performance criteria. - Updated supporting documentation including concepts of operations, flight test and safety plans, lifecycle cost estimates, and transition plans. - Completed final integration and checkout of initial guided test vehicle in preparation for flight testing. - Completed end-to-end system flight demonstration of initial test missile. - Developed booster adapter structure which mates standard Mk-114 booster clamp to missile body aft end. - Completed detailed design of new hybrid canister. - Analyzed shock and fly-out performance for the missile and canister. - Completed minor airframe design modifications for canister fit and internal structure/composite skin strengthened to react to vertical launch loads. ***FY 2014 Plans:*** - Complete missile and canister integration for a surface launched system. - Perform one controlled test vehicle flight from the Vertical Launching System. - Validate demonstrated system performance. - Complete final integration and checkout of final guided test vehicles in preparation for flight testing. - Complete end-to-end system flight demonstrations on final test missiles.			
Title: Integrated Hypersonics (IH) ***Description:*** The goal of the Integrated Hypersonics (IH) program was to develop, mature, and test next-generation technologies needed for tactical to global-range, maneuverable, hypersonic flight. IH sought to achieve technological advances in the areas of: next generation aero-configurations; thermal protection systems and hot structures; hypersonic airbreathing propulsion, adaptive guidance, navigation, and control; enhanced range and data collection methods; and advanced propulsion concepts, including real-time trajectory planning. The IH program addressed technical challenges and improved understanding of boost-glide and airbreathing hypersonic flight through innovative ground-based testing, expanded modeling and simulation, and advanced analytic methods. The Integrated Hypersonics (IH) program results are planned for transition to the Air Force and the Navy. ***FY 2013 Accomplishments:*** - Implemented improvements in highly coupled hypersonic toolsets incorporating assessed uncertainties of key technologies from prior flight tests and ground testing. - Refined hypersonic boost glide knowledge base and designs through enhanced developmental testing in the areas of aerodynamics, aerothermodynamics, guidance, navigation and control, and instrumentation. - Improved high temperature materials base for hypersonic flight and re-entry vehicles applications through improved manufacturing, modeling, and ground based testing. - Improved flight test range asset affordability and mission flexibility including options for large scale telemetry collection.	12.540	-	-

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated focused hypersonic technology development efforts to advance the state-of-the-art in analytic methods, computational modeling and simulation, and ground-based testing of technologies. - Began trade space analysis for tactical range hypersonic boost glide systems. - Completed Hypersonic Test Vehicle-2 remediation activities.			
Title: Integrated Sensor Is Structure (ISIS) ***Description:*** The joint DARPA/Air Force Integrated Sensor Is Structure (ISIS) program performed technology risk reduction to support prospective future development of a stratospheric airship containing a radar of unprecedented dimensions that will address the nation's need for persistent wide-area surveillance, tracking, and engagement of time-critical air and ground targets. The ISIS risk-reduction effort melded next-generation technologies for lightweight antenna apertures and components and lightweight multi-purpose structures. The ISIS technology concept goal was to provide greater than ninety percent on-station 24/7/365 availability for simultaneous Airborne Moving Target Indicator (AMTI) (600 kilometers) and Ground-Based Moving Target Indicator (GMTI); greater than five years of autonomous, unmanned flight; in-theater communications links; and CONUS-based sensor analysis and operation. The current technology risk-reduction efforts were focused on demonstrating the key technologies that would enable these capabilities. ***FY 2013 Accomplishments:*** - Conducted X-band metrology testing in anechoic chamber, demonstrating that the metrology algorithms can automatically compensate for array distortions. - Formulated ISIS test plan to support ground testing of the ISIS risk reduction radar. - Developed hardware/firmware for back-end processing of ISIS radar data. - Conducted trade studies and materials characterizations to select seaming material/processes. - Conducted trade studies and analyses to support development of low-damage fabrication and assembly processes for airship hull assembly. - Redesigned the power system to use alternate membrane technology. - Developed an ISIS fuel cell subsystem based on alternate membrane technology and evaluated subsystem performance. - Installed a combination of UHF/X-band dual band panels and UHF-only panels and radar back end into ISIS test facility. - Tested, characterized, and evaluated ISIS risk-reduction radar and demonstrated the radars ability to detect, track, and locate airborne targets.	5.000	-	-
Title: Triple Target Terminator (T3) ***Description:*** The Triple Target Terminator (T3) program developed a high speed, long-range missile to engage air, cruise missile, and air defense targets. T3 would be carried internally on stealth aircraft or externally on fighters, bombers, and UAVs. The enabling technologies are: air breathing propulsion, advanced networking and data links, and flexible guidance and control. T3	42.700	-	-

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
would allow any aircraft to rapidly switch between air-to-air and air-to-surface capabilities. T3's speed, maneuverability, and network-centric capabilities would significantly improve U.S. aircraft survivability and increase the number and variety of targets that could be destroyed on each sortie. The program is jointly funded with, and will transition to the Air Force. ***FY 2013 Accomplishments:*** - Fabricated and ground tested flight test articles. - Obtained final flight test approval from Point Mugu Test Range. - Conducted propulsion testing of flight weight engines. - Completed flight qualification of Flight Termination System (FTS). - Completed qualification of several subsystem components. - Completed ground tests of flight test articles. - Conducted captive carry test of flight test articles. - Conducted separation tests of flight test articles. - Completed propulsion testing of flight weight engines. - Completed build and assembly of flight test articles. - Conducted boost tests of flight test articles. - Conducted airborne launch demonstrations of test articles against three target types. - Completed and delivered final test report.			
Title: Vulture ***Description:*** The objective of the Vulture program was to demonstrate the required technology to enable an airborne payload to remain persistently on-station, uninterrupted and unreplenished, for over five years performing strategic and tactical communications, position/navigation/timing (PNT) and intelligence, surveillance, and reconnaissance missions over an area of interest. The Vulture concept envisioned a re-taskable, persistent pseudo-satellite capability, in a notional aircraft package. The program conducted subscale demonstration activities to prove out critical technologies. ***FY 2013 Accomplishments:*** - Conducted tests of anti-reflective coatings for the solar arrays and provided the anti-reflective analysis report. - Completed solar array iteration #1 testing. - Developed engineering ground demonstrator and flight-like ground demonstrator for energy storage system. - Completed the design and analysis for a peak power tracker for the solar arrays. - Completed an open-loop system design for an energy storage system. - Completed the energy storage system composite materials report.	5.773	-	-
Accomplishments/Planned Programs Subtotals	168.376	144.804	129.723

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603286E / *ADVANCED AEROSPACE SYSTEMS*

D. Other Program Funding Summary ($ in Millions)

Line Item	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
• Integrated Sensor Is Structure: *Air Force PE 0305205F, Project 675372F*	13.001	1.000	-	-	-	-	-	-	-	Continuing	Continuing
• Integrated Sensor Is Structure:: *Air Force PE 0603203F, Project 665A*	0.750	-	-	-	-	-	-	-	-	-	-
• Triple Target Terminator (T3): *Air Force*	41.730	-	-	-	-	-	-	-	-	Continuing	Continuing

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND 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	-	136.427	142.546	179.883	-	179.883	169.626	227.139	231.935	242.587	-	-
SPC-01: *SPACE PROGRAMS AND TECHNOLOGY*	-	136.427	142.546	179.883	-	179.883	169.626	227.139	231.935	242.587	-	-

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

A. Mission Description and Budget Item Justification

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

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

Systems development is also required to increase the interactivity of space systems, space-derived information and services with terrestrial users. Studies under this project include technologies and systems that will enable satellites and microsatellites to operate more effectively by increasing maneuverability, survivability, and situational awareness; enabling concepts include novel propulsion/propellants, unique manufacturing processes; precision control of multi-payload systems, and payload isolation and pointing systems.

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	159.704	172.546	169.757	-	169.757
Current President's Budget	136.427	142.546	179.883	-	179.883
Total Adjustments	-23.277	-30.000	10.126	-	10.126
• Congressional General Reductions	-0.211	-			
• Congressional Directed Reductions	-12.738	-30.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-6.194	-			
• SBIR/STTR Transfer	-4.134	-			
• TotalOtherAdjustments	-	-	10.126	-	10.126

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004, sequestration adjustments, reprogrammings, and the SBIR/STTR transfer.
FY 2014: Decrease reflects program termination of System F6.
FY 2015: Increase reflects expansion of funding for the XS-1 Experimental Spaceplane.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Airborne Launch Assist Space Access (ALASA)	29.237	42.500	55.000

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

FY 2013 Accomplishments:
- Completed initial test plans for flight demonstrator.
- Completed risk management plan.

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Conducted preliminary design review and selected enabling and enhancing technologies for incorporation into system concepts. - Conducted critical design review and initiated detailed design. - Integrated selected enabling and enhancing technologies on launch assist aircraft. ***FY 2014 Plans:*** - Conduct trade studies of additional enabling technology to include propellants, manufacturing, mission planning and range support software, and tracking and flight termination software. - Conduct critical design review of demonstration system and develop flight demonstrator. - Complete ALASA vehicle flight readiness review. - Perform propulsion and system risk reduction testing. - Conduct captive carry and aircraft compatibility flight tests. ***FY 2015 Plans:*** - Initiate demonstration of ALASA vehicle launches including launch readiness reviews. - Conduct launches to demonstrate program goals, including 100 pounds into low earth orbit. - Conduct analysis of launch performance metrics and identify opportunities for system design and integration optimization. - Continue transition coordination.			
Title: Space Domain Awareness (SDA) ***Description:*** The goal of the Space Domain Awareness (SDA) program is to develop and demonstrate an operational framework and responsive defense application to enhance the availability of vulnerable space-based resources. Current space surveillance sensors cannot detect, track, or determine the future location and threat potential of small advanced technology spacecraft in deep space orbits, where a majority of DoD spacecraft are located. Additionally, servicing missions to geosynchronous (GEO) orbits will require exquisite situational awareness, from ultra-high-accuracy debris tracking for mission assurance at GEO orbits to high resolution imaging of GEO spacecraft for service mission planning. The SDA program will develop a space management system that allows cognitive reasoning and decision support to execute space operations with current and proposed assets within real and synthetic environments. SDA will investigate revolutionary technologies in two areas: 1) advanced space surveillance sensors to better detect, track, and characterize space objects, with an emphasis on deep space objects, and 2) space surveillance data collection and data processing/ fusion to provide automated data synergy. The resulting increase in space domain awareness will enhance overall space safety of flight, and allow space operators to make informed, timely decisions. The SDA program will leverage data fusion and advanced algorithms developed under the Space Surveillance Telescope (SST) program, as well as seek to exploit new ground-breaking technologies across the electromagnetic spectrum and utilize already existing sensor technology in non-traditional or exotic ways, to bring advanced capabilities to the space domain. SDA will correlate a wide range of operational	18.000	18.000	19.883

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
support and space system user data to rapidly identify threat activities, propose mitigating countermeasures, and verify the effectiveness of selected responses. Critical technologies include accessing disparate sources of relevant data, model-based situational awareness, and candidate response generation and evaluation. Particular emphasis will be placed on the ability to continuously adapt to changes in defended system components and usage patterns as well as validation of system integrity. SDA will demonstrate new approaches to collection of data utilizing a variety of collection modalities, ranging from fusion of observations from non-traditional sources, such as amateur astronomers, to evaluation of sparse aperture imaging techniques. Also funded within this program is the Galileo effort which, will develop technology to image a Geosynchronous Earth Orbit (GEO) satellite from the ground. Galileo will utilize fixed mobile telescopes, each with adaptive optics and a guide star, to create multiple baselines that can be used to reconstruct the image through an inverse Fourier transform. The potential transition customer is the Air Force. ***FY 2013 Accomplishments:*** - Commenced radiometric data processing efforts. - Completed SpaceView initial demonstration, providing Space Situational Awareness (SSA) data from amateur astronomer sources. - Developed requirements performance models for the Galileo imaging system. - Developed plans for risk-reduction experiments necessary to complete a detailed Galileo system design. ***FY 2014 Plans:*** - Demonstrate the advantages of a having a collaborative network of users with access to data from numerous distributed sensors over the traditional sensor-centric architecture. - Expand SpaceView amateur network. - Initiate and demonstrate StellarView network of academic astronomy data providers. - Initiate novel dynamic database to collect networked source information for validation. - Demonstrate intuitive applications and adaptive understanding capabilities of the next-generation space information fusion center. - Complete risk reduction experiments and begin preliminary system design for the Galileo interferometer. - Study the application of quantum optical sensing methods to Space Domain Awareness challenges of object detection and imaging. - Commence Phase 1 of an un-cued low inclined LEO object detection capability. - Demonstrate preliminary capability of the Allen Telescope Array to passively detect and track satellites. - Commence astrometric data processing and validation efforts. - Commence Galileo Phase 2A risk reduction experiments to lead to possible future comprehensive demonstration.			

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Commence SpaceView Phase 2 to demonstrate additional amateur nodes including Australia locations. - Conduct a survey of operational management systems for Real-Time Space Domain Awareness. ***FY 2015 Plans:*** - Perform database verification on collected data; demonstrate metric and radiometric accuracy. - Continue SpaceView and StellarView data collections. - Complete preliminary system design of the Galileo interferometer. - Continue utilizing the OrbitOutlook Data Archive to dynamically archive diverse datasets. - Set-up for comprehensive demonstration in FY 2016. - Initiate Real-Time Space Domain Awareness design development.			
Title: Space Surveillance Telescope (SST)	10.204	8.000	8.000
Description: The Space Surveillance Telescope (SST) program has developed and demonstrated an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. A major goal of the SST program, to develop the technology for large curved focal surface array sensors to enable an innovative telescope design combining high detection sensitivity, short focal length, wide field of view, and rapid step-and-settle to provide orders of magnitude improvements in space surveillance has been achieved. This capability enables ground-based detection of un-cued objects in deep space for purposes such as asteroid detection and space defense missions. The initial program is transitioning to Air Force Space Command. In addition, the program is investigating data fusion and advanced algorithms for correlation of unknown objects. SST is expected to generate a large number of uncorrelated targets (UCTs), and new methods will need to be employed to rapidly characterize and attribute the new objects. Furthermore, the data fusion effort is investigating methods which combine observations from disparate sensors (such as optical and radar installations) to more rapidly, accurately, and completely provide positive identification of orbital objects, rapidly characterize them, and maintain a catalog of determined characteristics. The SST Australia effort will provide a further operational demonstration of the SST at the Naval Communication Station Harold E. Holt near Exmouth, Western Australia. Such a location presents a more operationally relevant demonstration, with a richer and more interesting population of SSA targets in geosynchronous orbit. A demonstration in Australia will investigate telescope performance and observe objects and orbits not visible from the current site in New Mexico. In addition, the demonstration will generate data for analysis and fusion efforts, which will be used to further refine and evaluate data processing techniques, such as those developed under the data fusion effort. This program will address technical challenges which may arise from an Australian site, including adaptations to a different telescope environment, and the logistical and communications challenges presented by a site significantly more remote than the current SST location.			

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Transitioned data fusion services to users. - Completed operational testing to enable military utility assessment of SST. - Completed investigation and selection of the SST location in Australia. - Completed SST relocation plan. ***FY 2014 Plans:*** - Continue evaluation of operational strategies, technology studies, and hardware demonstrations in order to optimize SST performance at Australia site. - Continue research at Atom site into technical challenges facing the system after relocation. - Complete MOA with Australia. - Refine SST relocation plan, jointly with the Australia Department of Defense partners. - Initiate enclosure subsystem design. ***FY 2015 Plans:*** - Disassemble SST in New Mexico. - Ship SST to Australian site. - Begin site preparation in Australia. - Complete enclosure subsystem design.			
Title: Phoenix ***Description:*** To date, servicing operations have never been conducted on spacecraft beyond low earth orbit (LEO). A large number of national security and commercial space systems operate at geosynchronous earth orbit (GEO) altitudes, furthermore, many end-of-life or failed spacecraft drift without control through portions of the GEO belt, creating a growing hazard to operational spacecraft. Technologies for servicing of spacecraft with the expectation that such servicing would involve a mix of highly autonomous and remotely (i.e., ground-based) teleoperated robotic systems have been previously pursued. The Phoenix servicing program will build upon these legacy technologies, tackling the more complex GEO environment and expanding beyond pure traditional servicing functions. The program seeks to validate robotics operations in GEO suitable for a variety of potential servicing tasks with a Servicer/Tender, in full collaboration and cooperation with existing satellite owners. The program will examine utilization of ride-along capability to GEO supporting upgrading, repairing, assembling, and reconfiguring satellites. The program will include an early LEO flight experiment focused on satlets, as a path of risk reduction for modular assembly on orbit. Key challenges include robotic tool/end effector requirements, efficient orbital maneuvering of a servicing vehicle, robotic arm systems, and integration and efficient and low cost transportation of robotic tools. The anticipated transition partners are the Air Force and commercial spacecraft servicing providers.	40.475	60.046	65.000

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Completed preliminary design of robotic servicing payload architecture and systems for Phoenix vehicle. - Developed payload orbital delivery systems (PODS) designs for commercial satellite ride-along as well as first working prototype for dispensement. - Initiated flight scale build of first satlets and demonstrated aggregation of performance functions in a ground testbed. - Initiated development and build of robotic servicing components including tools and toolbelt systems and selected a complete complement of tools for Phoenix. - Initiated six degree of freedom testbed on ground; began virtual system testing with the primary and secondary robotic arms. - Initiated telepresence simulation and began test qualification and training standards for Phoenix robotic operations. - Built first prototype of sensor suite for guidance and control on servicer and evaluated it with actual flight software algorithms. ***FY 2014 Plans:*** - Complete critical design of robotic servicing system including primary and secondary robotic arms and toolbelt. - Deliver prototypes of various servicing tasks to robotic testbed for validation and integration with tools. - Complete mission validation testing inside a six degree of freedom testbed. - Complete critical design of tele-operations system. - Conduct pre-ship review for early LEO satlet experiment equipment and deliver to launch integrator. ***FY 2015 Plans:*** - Launch early LEO satlet experiment and conduct experiment operations. - Complete delta critical design of satlets per lessons learned from LEO experiment. - Complete delta critical design of PODs. - Validate specific servicing mission types that maximize commercial and DoD operations. - Validate primary and secondary robotic hardware and software.			
Title: Experimental Spaceplane One (XS-1)* ***Description:*** *Formerly Small Responsive Space Access X-Plane The XS-1 program will mature the technologies and operations for low cost, persistent and responsive space access and global reach. Past efforts have identified and demonstrated critical enabling technologies including composite or light weight structures, propellant tanks, thermal protection systems, rocket propulsion and advanced avionics/software. A critically important technology gap is integration into a flight demonstration able to deliver aircraft-like operability. The program will validate key technologies on the ground, and then fabricate an X-Plane to demonstrate: 1) 10 flights in 10 days, 2) Mach 10+ flight, and 3) 10X lower cost space access for cargoes 3,000-5,000 lbs to low earth orbit. A key goal is validating the critical technologies for a wide range of next generation high speed aircraft enabling new military capabilities including worldwide reconnaissance, global transport,	-	10.000	27.000

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
small responsive space access aircraft and affordable spacelift. The anticipated transition partners are the Air Force, Navy and commercial sector. ***FY 2014 Plans:*** - Develop a conceptual design for the XS-1 demonstration system including detailed structural analysis and mass properties. - Perform system level trade studies to identify alternative configurations and define the tradespace for XS-1. - Accomplish planning activities to prepare for contract award. ***FY 2015 Plans:*** - Perform analysis on risk mitigation strategies for the propulsion system, thermal protection system and composite materials. - Conduct a mid-phase Conceptual Design and Systems Requirements Review. - Conduct component and subsystem testing and verification. - Conduct a Preliminary Design Review (PDR) and select a single vendor for final design, fabrication and flight test.			
Title: Optical Aperture Self-Assembly in Space (OASIS) ***Description:*** The Optical Apertures Self-assembling in Space program seeks to demonstrate the feasibility of constructing large optical apertures in orbit from a number of smaller modular components that self-organize in space. The program will demonstrate the technologies needed to assemble a large (>5m) and near-diffraction limited optical aperture from modular components that are launched as separate payloads. The program will include a scalable zero-g demonstration of a functional optical system that maintains the precision and large-scale physical stability required, and utilizes at least one segmented optical surface. This program will address technical challenges of precision mechanical assembly from modular components, multiple object rendezvous and coupling in space, and active surface measurement, compensation and control. Modular construction in space is intrinsically more challenging than ground-based assembly in that there is not necessarily any measurement and support infrastructure and equipment available, such as interferometer test towers. Therefore, the modular pieces and system design must include self-contained measurement and alignment capabilities to be employed after or during assembly. The OASIS program will demonstrate the feasibility of assembling complex and highly precise structures in space which, in assembled form, are larger than the capacity of any existing or planned space launch vehicle. This capability could enable a number of surveillance and communications instruments in orbit that are not possible today or in the near future under the current paradigm. The anticipated transition partners are the Air Force, Navy and commercial sector. ***FY 2015 Plans:*** - Investigate essential technologies to facilitate self-organizing robotic construction in space. - Conduct ground-based risk reduction experiments for critical path technologies.	-	-	5.000

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Identify potential effort to provide high resolution capability with light weight optics by leveraging a precision interferometric approach combined with novel image reconstruction algorithm and photonic integrated circuit.			
Title: System F6	30.000	3.000	-

Description: The objective of the System F6 program is to demonstrate the feasibility and benefits of satellite architecture technologies which facilitate a fractionated architecture wherein the functionality of a traditional "monolithic" spacecraft is replaced by a cluster of wirelessly-interconnected spacecraft modules. Each such "fractionated" module could contribute a unique capability, for example, computation and data handling, communications relay, guidance and navigation, payload sensing, or it can replicate the capability of another module; the cluster would deliver a comparable mission capability to a monolithic spacecraft. The fractionated modules would fly in a loose, proximate cluster orbit capable of semi-autonomous reconfiguration or a rapid defensive scatter/re-gather maneuver. The System F6 program will develop key technologies to facilitate fractionated and disaggregated architectures. The F6 Technology Package (F6TP), a suite of technologies, components, and algorithms that enables semi-autonomous multi-body cluster flight and secure, distributed, real-time sharing of various spacecraft resources at the cluster level will also be developed. Multiple versions of the F6 Technology Package will be developed on the basis of open-source interface standards, software, and reference designs termed the F6 Developer's Kit (FDK). The utility of the architecture in low earth orbit (LEO) is significantly enabled by persistent broadband connectivity to the ground which allows resource sharing between space-based modules and terrestrial network nodes. A solution to enable high-availability, low-latency, persistent, high-bandwidth communication with LEO spacecraft will be developed in the course of the F6 program.

FY 2013 Accomplishments:
- Completed initial version of FDK software and demonstrated functionality in representative orbital conditions.
- Completed initial release of the FDK.
- Conducted preliminary design review (PDR) for the F6TP.
- Conducted critical design review (CDR) for the F6TP.
- Took delivery of the F6TP breadboards.
- Completed FDK documentation for the wireless intermodule communications and information assurance platform architectures.

FY 2014 Plans:
- Complete F6TP engineering development units.
- Complete flight unit of the persistent broadband terrestrial connectivity terminal for LEO fractionated clusters.
- Complete a fully-functional, well-documented, value-centric architecture and design tool for adaptable space systems.
- Complete cluster flight application software development and testing.

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete academic research in the areas of theoretical exploration of value-centric design impacts as well as architectures for distributed real-time and embedded systems.			
Title: SeeMe	8.511	1.000	-
Description: The Army, Air Force, intelligence community, and other potential users require affordable support to the tactical warfighter via space. The goal of the SeeMe program is to demonstrate the ability to get near-real-time, i.e., no older than ~90 minutes, images directly to individual users' handheld devices from space. This will be accomplished via a very low cost constellation of inexpensive, disposable small satellites routinely and inexpensively put in orbit through low cost horizontal (aircraft-released) launches. The current methodology for satisfying imagery needs from space is to build multipurpose systems with very high reliability and long life, at very high costs, and launch them on expensive vertical launch boosters. In most cases, commercial or military, the time to deliver an already built space intelligence, surveillance, and reconnaissance system suitable to meet tactically desired ground sample distance is on the order of 20+ months, and the data delivery mechanism is typically more than several days (and up to weeks) to the end user. SeeMe intends to radically shorten the entire cycle: ground development time, launch cadence, and on-orbit request-to-image-delivery time through new satellite manufacturing techniques, advanced low-cost aperture technologies, leveraging alternative launch concepts, and a novel direct-to-user command and data exfiltration architecture. The anticipated transition partners are the Air Force and the Army. ***FY 2013 Accomplishments:*** - Completed trade studies on hardware design and constellation options that show trades between altitude, resolution and delivery time after request to ground user. - Executed technical prototype integration options for hardware level development. - Demonstrated applicability to commercial production environment using commercial off the shelf (COTS) based hardware. - Began verification of radio frequency and optical aperture template and began prototype construction. - Completed ground user hardware interface study/development, including specific ConOps with warfighter in the field. - Completed hardware- and system-level risk reduction tests, including thermal cycling tests, initial field tests, and balloon flight tests for enabling technologies for optics, deployable antennas, radio communication and high performance computing and algorithms. ***FY 2014 Plans:*** - Prepare critical design of system hardware and software for the satellites. - Complete prototype hardware field demonstrations (through balloon testing) to support radio link and downlink direct to user handhelds. - Complete technology prototype units, perform functional and environmental tests, and demonstrate operation.			
Accomplishments/Planned Programs Subtotals	136.427	142.546	179.883

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603287E / *SPACE PROGRAMS AND TECHNOLOGY*

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

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

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Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*

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	-	92.291	107.080	92.246	-	92.246	83.198	97.496	107.594	114.417	-	-
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	-	36.797	32.336	12.386	-	12.386	-	-	-	-	-	-
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	55.494	74.744	79.860	-	79.860	83.198	97.496	107.594	114.417	-	-

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

A. Mission Description and Budget Item Justification

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

The MicroElectroMechanical Systems (MEMS) and Integrated Microsystems Technology project is a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems to address issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. The project will also address thermal management, navigation and positioning technology challenges.

The goal of the Mixed Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems. These 'wristwatch size', low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. The chip assembly and packaging processes currently in use produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration of mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'. The ability to integrate mixed technologies onto a single substrate will increase performance and reliability, while driving down size, weight, volume and cost.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	111.008	117.080	159.229	-	159.229
Current President's Budget	92.291	107.080	92.246	-	92.246
Total Adjustments	-18.717	-10.000	-66.983	-	-66.983
• Congressional General Reductions	-0.147	-			
• Congressional Directed Reductions	-7.477	-10.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-8.181	-			
• SBIR/STTR Transfer	-2.912	-			
• TotalOtherAdjustments	-	-	-66.983	-	-66.983

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004, sequestration adjustments, reprogrammings, and the SBIR/STTR transfer.
FY 2014: Decrease reflects a reduction for prior year carryover.
FY 2015: Decrease reflects programs in thermal imaging coming to an end, micro position, navigation and timing scaling back and elimination of maskless nano-writer follow-on.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	Project (Number/Name) MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS 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
MT-12: *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*	-	36.797	32.336	12.386	-	12.386	-	-	-	-	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Micro-Technology for Positioning, Navigation, and Timing (Micro PN&T)	35.492	27.725	12.386

Description: The Micro-Technology for Positioning, Navigation, and Timing (Micro-PN&T) program is developing low size, weight, power, and cost (SWaP+C) inertial sensors and timing sources. This suite of sensors, when integrated into an inertial measurement unit (IMU), will enable self-contained navigation and timing in the absence of signals from the Global Positioning System (GPS), due to environmental interference or adversary action such as GPS jamming. The Micro-PNT program is developing miniature high performance gyroscopes, accelerometers, and clocks, based on both solid state and atomic technologies. Advanced micro-fabrication techniques under development will enable the fabrication of a single package containing all the necessary devices in a volume the size of a sugar cube. The small SWaP+C of these technologies will enable ubiquitous guidance and navigation on all platforms, including guided munitions, unmanned aerial vehicles (UAVs), and individual soldiers.

The successful realization of Micro-PN&T requires the development of new microfabrication processes and novel material systems for fundamentally different sensing modalities, understanding of the error sources at the micro-scale, and development of micro-scale systems for sensors based on atomic physics techniques. Innovative 3-D microfabrication techniques under development will allow co-fabrication of dissimilar devices on a single chip, such that clocks, gyroscopes, accelerometers, and

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
calibration stages can be integrated into a small, low power architecture. The program is developing miniature atomic clocks, based on laser-cooled neutral atoms and trapped ions as well as inertial sensors based on atomic interferometry and nuclear magnetic resonance. Applied research for this program is funded within PE 0602716E, Project ELT-01. ***FY 2013 Accomplishments:*** - Developed monolithic microfabrication process to co-integrate clock, accelerometers and gyroscopes into 10mm^3. - Demonstrated functionality of a co-fabricated 10 mm^3 IMU. - Developed an automated test station to provide extended testing for a Nuclear Magnetic Resonance (NMR) gyroscope. - Developed 3D micro shell resonators with integrated electrodes for drive and sense. - Modeled the internal and external sources of error, scale-factor, and bias drift of inertial devices for successful on-chip calibration. - Demonstrated small ion clocks with fractional frequency stability of 5e-14 after one month of operation. - Demonstrated NMR gyro operation up to 2,500deg/s rotation with turn-key operation. - Demonstrated efficacy of zero velocity updating and ultrasonic ranging for calibration of an IMU in dismount applications, achieving accuracy of position tracking to 4m after 2 hours of navigation. ***FY 2014 Plans:*** - Demonstrate and evaluate performance of miniature atomic physics-based inertial sensors. - Fabricate low loss spherical shell resonators, with quality factor (Q) over 1 Million, for gyroscope applications. - Evaluate performance of a complete 6-degree of freedom IMU with a volume of < 10 mm^3. - Demonstrate gyroscope self-calibration with long-term scale factor and bias of <10 ppm of full range. ***FY 2015 Plans:*** - Demonstrate hybrid IMU, including integration of atomic physics based and solid state based sensors in a compact system with startup time less than one minute. - Demonstrate gyroscope self-calibration with long-term scale factor and bias of <1 ppm of full range. - Demonstrate portable high-performance atomic frequency standard.			
Title: Blast Exposure Accelerated Sensor Transfer (BEAST)	1.305	4.611	-
Description: The Blast Exposure Accelerated Sensor Transfer (BEAST) program is a follow-on program to the Blast Gauge program. Blast-related injuries have emerged as the signature wounds of recent conflicts. To better understand the level of blast exposure received by warfighters, which is critical for developing and providing better treatment, low-cost personal sensors to record such critical signatures as blast overpressure had to be developed. DARPA rapidly developed and fielded the Blast Gauge to better understand the combat exposures responsible for these injuries by properly capturing relevant data at the time of injury. The gauges have been effective at capturing such events during operations in Afghanistan, achieving a number of milestones			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
from the first recording during an IED attack to the first use of sensor data in medical evaluation of a service member with Traumatic Brain Injury (TBI). Unexpectedly, gauge recordings have shown that potentially hazardous exposures may also occur in noncombat situations. Typically these happen during training using weapon systems. As the Blast Gauge is being deployed, military services require additional tools to begin properly using the device. The Blast Exposure Accelerated Sensor Transfer (BEAST) program is a 1-year effort to provide additional tools for users and complete transition to military service sustainment. ***FY 2013 Accomplishments:*** - Outfitted all task force members of the Combined-Joint-Special-Operations-Task-Force-Afghanistan with Blast Gauges. - Conducted laboratory evaluation and end-user-assessments demonstrating that the Blast Gauges work as designed. - Provided Blast Gauge technical support to Marines in Afghanistan. - Discovered that training exercises present a risk of blast exposure. - Measured and provided data on training exposures to all U.S. military services. - Established mathematical and operational techniques to provide a detailed recreation of blast events from sensor measurements and operational data. - Supported independent evaluations of Blast Gauge technology by the Army and Marines that concluded Blast Gauges work effectively and offer a dependable platform for identifying injury. ***FY 2014 Plans:*** - Support medical studies using Blast Gauges as part of studies into the root causes of Traumatic Brain Injury. - Provide end user training and support in the battlespace and CONUS. - Complete a database to store and organize Blast Gauge recordings, sustainment, and transition and develop a web-based front-end to the database. - Develop tools to analyze and visualize data uploaded to the database. - Validate and refine the re-creation process. Controlled blast testing will be done with the data used to reconstruct the event. - Expand the event reconstruction capability.			
Accomplishments/Planned Programs Subtotals	36.797	32.336	12.386

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-12 / *MEMS AND INTEGRATED MICROSYSTEMS TECHNOLOGY*

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 / 3	R-1 Program Element (Number/Name) PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	Project (Number/Name) MT-15 / *MIXED TECHNOLOGY INTEGRATION*	

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
MT-15: *MIXED TECHNOLOGY INTEGRATION*	-	55.494	74.744	79.860	-	79.860	83.198	97.496	107.594	114.417	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Endurance	14.588	22.800	36.747
Description: The Endurance program will develop technology for pod-mounted lasers to protect a variety of airborne platforms from emerging and legacy electro-optical IR guided surface-to-air missiles. The focus of the Endurance effort will be to develop			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
and test ancillary subsystems, such as a command subsystem, a threat missile warning subsystem, a mechanical support framework, subsystem interfaces, and the design, integration, and testing of a form/fit/function brass-board laser countermeasure. This program is an early application of technology developed in the Excalibur program and will transition via industry. Applied research for this program is budgeted in PE 0602702E, project TT-06. ***FY 2013 Accomplishments:*** - Completed risk analysis of subsystems and their integration: Identified low, medium, and high risk subsystems. - Produced System Requirements Documents (SRDs) and Interface Control Documents (ICDs). ***FY 2014 Plans:*** - Acquire threat devices and/or surrogates in preparation for live fire testing. - Complete the critical design of ancillary subsystems (power supply, thermal management, processing and control, mechanical support framework). - Complete the preliminary design for subsystem integration including optical and electrical interconnections and their layouts. ***FY 2015 Plans:*** - Complete the critical design for subsystem integration. - Integrate, assemble and bench-test the brassboard system. - Test the brassboard laser weapon system at an outdoor test range against a representative set of dynamic-threat targets.			
Title: Diverse & Accessible Heterogeneous Integration (DAHI)	-	17.944	20.300
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) effort will take this capability to the next level, ultimately offering the seamless co-integration of a variety of semiconductor devices (for example, Gallium Nitride (GaN), Indium Phosphide, Gallium Arsenide, Antimonide Based Compound Semiconductors), microelectromechanical (MEMS) sensors and actuators, photonic devices (e.g., lasers, photo-detectors) and thermal management structures. This capability will revolutionize our ability to build true "systems on a chip" (SoC) and allow dramatic size, weight and volume reductions for a wide array of system applications. This program has basic research efforts funded in PE 0601101E , Project ES-01 and applied research efforts funded in PE 0602716E, Project ELT-01 The Advanced Technology Development part of this program will leverage these complementary efforts to focus on the establishment of an accessible, manufacturable technology for device-level heterogeneous integration of			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
a wide array of materials and devices (including, for example, multiple electronics and MEMS technologies) with complex silicon-enabled (e.g. CMOS) architectures on a common silicon substrate platform. This part of the program is expected to culminate in accessible foundry processes of DAHI technology and demonstrations of advanced microsystems with innovative architectures and designs that leverage heterogeneous integration. By the end of the program, this effort seeks to establish a technologically mature, sustainable DAHI foundry service to be made available (with appropriate computer-aided design support) to a wide variety of DoD laboratory, Federally Funded Research and Development Center (FFRDC), academic and industrial designers. ***FY 2014 Plans:*** - Develop a high-yield, high-reliability accessible manufacturing process flow which will be transitioned to a self-sustaining foundry activity providing heterogeneously integrated circuits with four materials/device technologies (Silicon (Si) CMOS, Indium Phosphide (InP) Heterojunction Bipolar Transistor (HBTs), Gallium Nitride (GaN) High-electron-mobility transistor (HEMTs), and high-Q passive devices). - Establish heterogeneous integration design/simulation tool flows necessary to realize the full potential of heterogeneous microsystems integration. - Demonstrate capability for supporting multi-project wafer runs using the heterogeneous foundry service under development. - Accelerate development of circuit design techniques and methodologies that enable revolutionary heterogeneously integrated circuit architectures. ***FY 2015 Plans:*** - Continue to develop a high-yield, high-reliability accessible manufacturing process flow which will be transitioned to a self-sustaining foundry activity providing heterogeneously integrated circuits with four materials/device technologies (Si CMOS, InP HBTs, GaN HEMTs, and high-Q passive devices). - Continue to demonstrate capability for supporting multi-project wafer runs using the heterogeneous foundry service under development.			
Title: FLASH - Scaling Fiber Arrays at Near Perfect Beam Quality ***Description:*** The goal of the FLASH program is to demonstrate array combinations of ultra-lightweight high power fiber lasers that project 100-kW-class beams with near perfect beam quality and very high electrical-to-optical efficiency capable of enabling a variety of high-energy laser weapons applications. To accomplish these ends, FLASH will (1) greatly reduce the overall size and weight of high-power fiber lasers while increasing their robustness consistent with tactical and long-endurance aircraft integration, and (2) develop and demonstrate light-weight, high-power optical phased arrays and ultra-high bandwidth target-in-the-loop beam combination techniques for reducing necessary beam-projection profiles consistent with deployment in aircraft and near-perfect compensation for atmospheric turbulence. The completed high-energy laser system will provide technology enabling engagement of air, space, and ground targets at mission relevant ranges.	-	13.000	16.313

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2014 Plans: - Demonstrate an array of approximately 1.2 kW fiber-lasers combined to produce >30 kW near-diffraction-limited output at >30% electrical-to-optical efficiency. - Evaluate 21-element array system adaptive optical performance under various atmospheric and sea-surface conditions. - Demonstrate target-in-the-loop phase-locking on stationary and moving extended targets at 1-8km tactical distances. ***FY 2015 Plans:*** - Develop and test a coherently combinable, flight-worthy fiber laser with an output power, beam-quality, size and weight consistent with system integration on tactical aircraft. - Finish a comprehensive system design review of the entire laser system including fiber lasers, thermal management, power systems, and beam steering.			
Title: Direct SAMpling Digital ReceivER (DISARMER)	-	2.000	2.000
Description: The goal of the Direct SAMpling Digital ReceivER (DISARMER) program is to produce a hybrid photonic-electronic analog-to-digital converter (ADC) capable of directly sampling the entire X-band (8 -12 GHz). Conventional electronic wideband receivers are limited in dynamic range by both the electronic mixer and the back-end digitizers. By employing an ultra-stable optical clock, the DISARMER program will allow for mixer-less digitization and thereby improve the dynamic range 100x over the state of the art. Such a wide bandwidth, high fidelity receiver will have applications in electronic warfare and signals intelligence systems with the potential to drastically reduce the cost, size and weight of these systems. The DISARMER program will design, fabricate, and test a hybrid photonic-electronic ADC packaged in a standard form factor. This involves the integration of electronic and photonic circuits, packaging of a mode-locked laser with ultralow jitter, and delivering a field programmable gate array with the necessary firmware to process the sampled data. This program has applied research efforts funded in PE 0602716E, Project ELT-01. ***FY 2014 Plans:*** - Define system architecture and flow-down metrics for individual components. - Design a quantizer chip that will incorporate a hold/reset switch for each photodetector, an electronic quantizer capable of 5 bits, and an encoder to convert the optical output of the photonic processor to a digital code. - Design remote sampling head to incorporate electronic RF frontend, electro-optic modulator, and 4 GHz-wide filter. ***FY 2015 Plans:*** - Fabricate and perform preliminary test of opto-electronic quantizer chip. - Complete system engineering of field programmable gate array capable of continuous streaming of digital data.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate direct sampling of a 4 GHz-wide bandwidth signal at 7 effective bits of fidelity.			
Title: Direct On-Chip Digital Optical Synthesis (DODOS)	-	-	4.500
Description: The development of techniques for precise frequency control of RF and microwave radiation in the 1940s revolutionized modern warfare. Frequency control is the enabling technology for radar, satellite and terrestrial communications, and position-sensing and navigation technology, among many other core DoD capabilities. To date, however, optical frequency synthesis has been limited to laboratory environments due to the large size, relative fragility, and high cost of optical comb-based synthesizers. Recent developments on the DARPA Quantum Assisted Sensing and Readout (QuASAR) and in Ultrafast Laser Science and Engineering (PULSE) programs have demonstrated the possibility of generating self-referenced combs in microscale resonators. Combined with technology and fabrication techniques developed in the Photonically Optimized Embedded Microprocessor (POEM) and Diverse & Accessible Heterogeneous Integration (DAHI) programs, it is now possible to develop a chip-scale integrated optical frequency synthesizer. Ubiquitous low-cost robust optical frequency synthesis is expected to create a similar disruptive capability in optical technology as microwave frequency synthesis did in the 1940s, enabling high-bandwidth coherent optical communications, coherent synthesized-aperture LiDAR, portable high-accuracy atomic clocks, high-resolution standoff gas/toxin detection, and intrusion detection, among other applications. The Direct On-chip Digital Optical Synthesis (DODOS) program will create a microscale, high-accuracy optical frequency synthesizer, in a compact, robust package, suitable for deployment in a wide variety of mission-critical DoD applications. ***FY 2015 Plans:*** - Develop DODOS system architecture. - Optimize wavelength dispersion and low-threshold operation of micro-resonator based combs. - Investigate promising early systems demonstrations employing DODOS technology.			
Title: Low Cost Thermal Imager - Manufacturing (LCTI-M)	17.000	19.000	-
Description: The Low Cost Thermal Imager - Manufacturing (LCTI-M) effort builds upon previous manufacturing and imaging work and will develop a pocket-sized and smartphone-integrated, manufacturable, and practical thermal imager at a price point that allows it to be provided to large numbers of warfighters. Availability of very low cost and small form-factor infrared (IR) cameras will facilitate new techniques and applications that could provide the decisive edge needed in modern battlefields. These cameras will allow a soldier to have practical thermal imaging capability for locating warm objects (e.g., enemy combatants) in darkness. The small size, weight and power (SWaP) thermal camera will be integrated with a handheld device such as a cell phone with network capability for tactical intelligence, surveillance and reconnaissance. In order to achieve this goal, breakthroughs will be required in low-cost thermal imagers manufactured using wafer- scale integration, vacuum packaging, low-cost optics and low-power signal processing. By the end of the program, the imager chips will be fully integrated with a low-cost			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
processor and optics. The camera will have wireless connectivity to integrate video display with cell phones or PDAs. U.S. Army PEO Soldier Sensors and Lasers (SSL), PM Optics USMC, USSOCOM and industry will be the transition partners. ***FY 2013 Accomplishments:*** - Established interim small form-factor camera integration. - Demonstrated and delivered interim 640x480, 17 micrometer (µm) pixel-pitch LCTI-M camera. - Demonstrated 640x480 12 um pixel LCTI-M camera and imagery. - Finalized design of low cost IR optics for LCTI-M. - Demonstrated wafer-level optics with good uniformity across the wafer. - Demonstrated an integrated smart phone and first prototype thermal camera. - Initiated fabrication of 640x480- 10 µm-pitch microbolometers. - Completed design of camera electronics. ***FY 2014 Plans:*** - Complete low-cost wafer-scale optics for LCTI-M camera. - Demonstrate small-form-factor camera integration employing 3-D assembly techniques. - Deliver interim prototypes for testing. - Deliver final 640x480 LCTI-M cameras with test results and 1280X1024 camera engines.			
Title: Maskless Direct-Write Nanolithography for Defense Applications ***Description:*** The Maskless Direct-Write Nanolithography for Defense Applications program developed a maskless, direct-write lithography tool that addresses both DoD needs for affordable, high performance, Integrated Circuits (ICs) in small lots and the commercial market's need for highly customized, application-specific ICs. In addition, this program has provided a cost effective manufacturing technology for low volume nanoelectromechanical system (NEMS) and nanophotonic devices within the DoD. Transition will be achieved by installing maskless lithography tools into the Trusted Foundry and in commercial foundries, which will enable affordable incorporation of state-of-the-art semiconductor devices in new military systems, and allow for the cost-effective upgrade of legacy military systems. ***FY 2013 Accomplishments:*** - Designed and built a 4th generation electron-beam column capable of demonstrating 14 nm node lithography. - Designed and built a compact electrode stack lens demonstrating 100 kilovolts standoff. - Designed and built a permanent magnet lens demonstrating an axial field which gives 15 nm blur at a current of 2.5 microampere (µA) at the wafer plane. - Demonstrated gray-scale patterning capability on wafers using multiple resist chemistries with a line resolution of 200 nm and a blur of 40 nm at a wafer current of 1.06 µA.	14.476	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Designed and fabricated a third generation pattern generator device and passed Complementary metal-oxide-semiconductors (CMOS) electrical test at full speed and at all "corners."			
Title: Excalibur ***Description:*** The Excalibur program developed high-power electronically-steerable optical arrays, with each array element powered by a fiber laser amplifier. These fiber-laser arrays are sufficiently lightweight, compact, and electrically efficient to be fielded on a variety of platforms with minimal impact on the platform's original mission capabilities. Each array element possesses an adaptive-optic capability to minimize beam divergence in the presence of atmospheric turbulence, together with wide-field-of-view beam steering for target tracking. With each Excalibur array element powered by high power fiber laser amplifiers (at up to 3 kilowatts (kW) per amplifier), high power air-to-air and air-to-ground engagements have been enabled that were previously infeasible because of laser system size and weight. In addition, this program developed kilowatt-class arrays of diode lasers which provided an alternate route to efficiently reaching mission-relevant power levels, and they tested the ultimate scalability of the optical phased array architecture. Excalibur arrays are conformal to aircraft surfaces and scalable in size and power by adding additional elements to the array. Excalibur provided the technology foundation for defense of next generation airborne platforms, including all aircraft flying at altitudes below 50,000 ft, against proliferated, deployed, and next-generation man-portable air-defense systems (MANPADS) and more capable air-to-air missiles converted for use as ground-to-air missiles. Excalibur technology will enable these platforms to fly at lower altitude and conduct truly persistent, all-weather ground missions, such as reconnaissance despite low-lying cloud cover. Further capabilities may include multichannel laser communications, target identification, tracking, designation, precision defeat with minimal collateral effects as well as other applications. The Excalibur program also developed efficient high-power laser amplifier arrays based on coherent or spectral beam-combining. The potential of these arrays to scale to tactical power levels (100 kilowatt class) was also investigated. These laser amplifier arrays were designed to work in tandem with the core laser components developed under the Excalibur program in PE 0602702E, Project TT-06. In addition a conceptual design and CONOPS development for a High Energy Laser Counter Measure (HELCM) system were developed to enable a near-term capability for low-altitude self-defense against MANPADS. This technology will transition via industry, and will be incorporated into the Endurance program discussed earlier in this project (MT-15). ***FY 2013 Accomplishments:*** - Demonstrated 11.2 kW of combined optical output from 16 fiber lasers using hybrid beam combining. - Demonstrated beam combining (coherent or spectral) of twenty-one 1-kW fiber laser amplifiers. - Demonstrated coherent combining of a 19-element 2-D optical phased array with a combined power of 21 kW and tip/tilt adaptive optics. - Designed and built a mobile 21-element optical phased array with adaptive fiber-collimators.	3.035	-	-
Title: Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE)	6.395	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603739E / *ADVANCED ELECTRONICS TECHNOLOGIES*	**Project (Number/Name)** MT-15 / *MIXED TECHNOLOGY INTEGRATION*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: The Advanced Wide FOV Architectures for Image Reconstruction & Exploitation (AWARE) program primarily addressed the passive imaging needs for multi-band, wide field-of-view (FOV) and high-resolution imaging for ground and near-ground platforms. The AWARE program sought to solve the technological barriers to wide FOV, high resolution and multi-band camera architectures by focusing on four major tasks: high space-bandwidth product (SBP) camera architecture; small-pitch pixel focal plane array architecture; broadband focal plane array architecture; and multi-band focal plane array architecture. The AWARE program has advanced integration of technologies that enable wide field of view and high resolution and multi-band cameras, including the technologies demonstrated in the related AWARE program in PE 0602716E, Project ELT-01. AWARE aggregated the following programs: Lambda Scale, Broadband, Multi-Band and Wide Field of View. The integration of the technologies will enable next-generation focal plane arrays (FPAs) and cameras. Such focal plane arrays can also be used to fabricate very high pixel-count cameras for persistent surveillance applications. ***FY 2013 Accomplishments:*** - Optimized broadband detector array fabrication and assembly processes to maximize FPA operability. Hybridized 1024x1024, 18 µm-pixel-pitch detector arrays to readout integrated circuits. - Finalized camera integration and demonstrated broadband (0.5 to 5 µm) performance with 1024x1024, 18 µm-pixel-pitch FPA. - Fabricated and demonstrated 1280x720, 5 µm-pixel-pitch Long-Wave IR (LWIR) and Mid-Wave IR (MWIR) FPAs for imaging in cluttered and in brownout conditions. - Conducted initial field tests for MWIR rifle scope. - Delivered a camera with a 2Kx2K sensor to be used for evaluations under brownout landing conditions. - Completed the development of an algorithm for imaging through brown-out, and integration into an Field-Programmable Gate Array (FPGA).			
Accomplishments/Planned Programs Subtotals	55.494	74.744	79.860

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS 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	-	189.909	239.078	243.265	-	243.265	227.402	216.559	237.068	228.998	-	-
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	-	11.442	-	-	-	-	-	-	-	-	-	-
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	-	104.901	152.913	135.633	-	135.633	141.332	204.559	225.068	220.998	-	-
CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*	-	16.833	10.120	2.707	-	2.707	-	-	-	-	-	-
CCC-06: *COMMAND, CONTRO AND COMMUNICATION SYSTEMS*	-	56.733	76.045	104.925	-	104.925	86.070	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 Command, Control and Communications Systems program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

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

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

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

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	237.859	239.078	216.950	-	216.950
Current President's Budget	189.909	239.078	243.265	-	243.265
Total Adjustments	-47.950	-	26.315	-	26.315
• Congressional General Reductions	-0.284	-			
• Congressional Directed Reductions	-39.133	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.910	-			
• SBIR/STTR Transfer	-5.623	-			
• TotalOtherAdjustments	-	-	26.315	-	26.315

Change Summary Explanation

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

FY 2015: Increase reflects expansion of the Spectrum Efficiency and Access program and a new effort for Assured Beyond Line-of-Sight Communications.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-01 / *COMMAND & CONTROL INFORMATION 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
CCC-01: *COMMAND & CONTROL INFORMATION SYSTEMS*	-	11.442	-	-	-	-	-	-	-	-	-	-

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

A. Mission Description and Budget Item Justification

Military operations since the end of the Cold War show theater-level command, control, communications, and intelligence/information systems lack the ability to fully support operations in complex, time-critical environments. Warfighters must be prepared for operations ranging from peacekeeping in urban centers to heavy battle actions in remote areas. Current capabilities do not provide the commander with real-time, secure, situational awareness or the ability to orchestrate high-tempo planning, rehearsal, and execution. The program in this project was involved in the development and testing of innovative, secure architectures and tools to enhance information processing, dissemination, and presentation capabilities.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: ZETA ***Description:*** The ZETA program explored the aspects of novel physical devices, concepts, and techniques that leverage quantum physics for information technology. Research in this area has the ultimate goal of demonstrating information technology components with radical improvements in power efficiency and/or computational power relevant to military applications and opportunities. ***FY 2013 Accomplishments:*** - Demonstrated improved performance of key physical devices. - Fabricated samples with improved materials and demonstrated the expected increase in lifetime.	11.442	-	-
Accomplishments/Planned Programs Subtotals	11.442	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-01 / *COMMAND & CONTROL INFORMATION SYSTEMS*

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 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION 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
CCC-02: *INFORMATION INTEGRATION SYSTEMS*	-	104.901	152.913	135.633	-	135.633	141.332	204.559	225.068	220.998	-	-

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

A. Mission Description and Budget Item Justification

The success of military operations depends on timely, reliable, secure, and synchronized dissemination of command and control and relevant situational awareness information to every military echelon. While wired communications and networks are fairly well developed, providing assured high-bandwidth mobile wireless capabilities that match or exceed commercial wired infrastructure is needed to meet the demands of military users. The goal of the Information Integration Systems project is to develop and demonstrate technologies that will provide effective communications to U.S. forces. Approaches to this goal include developing technologies in these areas:

- High-Capacity Links technologies - enables greater back-haul capability
- Advanced Networking technologies - supports resilience, adaptability, and scalability
- Low Probability of Detection and Anti-Jam (LPD/AJ) technologies - provides assured communications in a very high-threat environments
- Novel Radio Frequency and Spectral Sensing (RF/SS) - supports efficient spectrum management in congested environments and detection of electromagnetic threats

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Fixed Wireless at a Distance	8.189	15.500	3.000

Description: Unlike commercial wireless communications, the military cannot count on a set of secure, fixed cell towers to establish wireless networks capable of receiving and distributing large amounts of data from distributed sources. Rather, such communication must rely on approaches such as balloons and temporary communication towers that have a high logistical burden and are extremely vulnerable. Building upon technologies investigated under other High-Capacity Links technologies programs within this project, the Fixed Wireless at a Distance program will overcome these limitations by developing a re-locatable, long-range (10-100s of km) communication infrastructure that provides high-capacity (10s of megabits per second) data links from within a protected space. The key innovation in this program is the use of a large number of rapidly deployable, distributed, ground-based antenna arrays that can form a coherent aperture for directional transmission and reception of information to/from tactical wireless networks. Program challenges include the fundamental limits (power and extent) of transmitter gain as well as the rapid and practical deployment of the ground-based arrays. When completed, the Fixed Wireless at a Distance program will significantly extend the reach of tactical communication systems without the need for vulnerable and costly infrastructure. Technologies developed in this program will transition to the Navy and Air Force.

FY 2013 Accomplishments:

- Assessed the fundamental limits of transmitter gain for a distributed ground-based wireless network.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated assessment of ground-based array to determine the required characteristics (number or antennas, spatial diversity, and power) to enable marked improvement in the range of tactical communication systems. ***FY 2014 Plans:*** - Field test collaborative beam focusing radios to measure power as a function of speed. - Build prototype infrastructure module supporting 4 channels divided between a legacy military waveform selected in the 2013 effort, and a CLASS extended range waveform. - Develop and test Application Specific Networking Patterns (ASNPs) networking software in a simulation environment to support mobile ad hoc communications with infrastructure using multiple military traffic use cases. - Measure network performance improvement, throughput and pervasiveness, comparing Mobile Ad Hoc Network with Gateway and Fixed Wireless network protocol. - Develop self-organizing communications software to automatically configure distributed communication systems without operator configuration. ***FY 2015 Plans:*** - Integrate Soldier Radio Waveform (SRW) capability with Fixed Wireless Infrastructure. - Perform a field test and demonstration of range and data rate of Fixed Wireless Infrastructure to CLASS-equipped radios and to SRW legacy radios. - Demonstrate temporal conjugation technique from multiple, distributed field locations. - Integrate a legacy waveform (e.g., Soldier Radio Waveform (SRW)) capability with Fixed Wireless Infrastructure. - Perform a field test and demonstration of range and data rate of Fixed Wireless Infrastructure to CLASS equipped radios and to SRW legacy radios. - Add two additional ASNPs to support transition of technology to service users.			
Title: Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART) ***Description:*** The Scalable Millimeter-wave (MMW) Architectures for Reconfigurable Transceivers (SMART) program developed a new technology for producing very thin millimeter-wave array apertures and transceivers. The technology development culminated in the demonstration of a large-sized coherent, active electronically-steerable array (AESA) with an output power density of 5W per square cm and a total layer thickness of less than 1cm. As part of the High-Capacity Links efforts in this Project, the SMART technology approach resulted in a breakthrough in performance over conventional millimeter-wave approaches. The 3-D multi-layer assemblies developed will greatly reduce AESA packaging complexity and enable very compact, low-cost, millimeter-wave, and radio frequency circuit "building blocks" to combine to form arbitrarily large arrays. New capabilities, such as the ability to construct reconfigurable and/or multi-band AESAs and other MMW circuits, will be enabled by this architectural approach. The SMART program is transitioning through industrial producers of MMW radar and communication system components for DoD applications.	3.000	6.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Built a W-band (94 GHz) SMART phased array prototype with transmit/receive capability. Successfully demonstrated the prototype in the laboratory as a range test set. ***FY 2014 Plans:*** - Initiate transition of SMART baseline sub-array module fabrication techniques toward realizing Manufacturing Readiness Level (MRL) 5 through yield analysis and implementation of identified process improvements. - Increase manufacturability and affordability of the SMART modules for mm-wave communication arrays through increased throughput of batch-fabricated modules.			
Title: 100 Gb/s RF Backbone ***Description:*** The proliferation of video, voice, chat, and other important data-streams on the battlefield is driving a need for higher capacity, reliable, assured, and all-weather communications that are deployable on a wide range of air, ground, and maritime platforms. The goal of this High-Capacity Links technologies program is to demonstrate a 100 Gigabit-per-second (Gb/s) radio frequency (RF) backbone that will meet the anticipated mid-term (within 3-10 years) wireless networking requirements of deployed military forces. DARPA's hybrid Free Space Optical RF Communications Adjunct (ORCA) system has broken the 10 Gb/s wireless network boundary using free-space optical links, but all-weather Ku band components are currently limited to much less than 1Gb/s capacity. Furthermore, the hybrid optical/RF system exhibits size, weight, and power (SWaP) consumption characteristics that preclude deployment on many SWaP-limited platforms. Moving to a millimeter-wave (mmW) solution will provide high capacity and all-weather resiliency, but presents technical challenges that include the generation of higher-order waveforms (beyond common data link), efficient power transmission, high-speed routing, and low-noise receivers. This program seeks to develop the constituent subsystems (waveform generation, efficient power amplifiers, and receivers) and spatial multiplexing architectures to construct an all-weather mmW 100 Gbps backbone at half the SWaP consumption of the current ORCA system. The 100 Gbps RF Backbone program is intended for transition to multiple Services. ***FY 2014 Plans:*** - Develop millimeter-wave waveforms with higher modulation constellation to achieve high spectral efficiencies. - Identify promising approaches to achieving power transmission efficiency improvements at mmW frequencies. - Identify promising low noise-figure receiver technologies for mmW frequencies. - Identify candidate architectures, hardware, and algorithms for spatial multiplexing to achieve high spectral efficiencies. ***FY 2015 Plans:*** - Build and evaluate modulators capable of generating high-order waveforms and demodulators capable of digitizing the high-order waveforms. - Evaluate high-order modulation approaches at mmW frequencies in field demonstrations to tactically relevant distances.	-	10.000	13.770

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Build and evaluate the hardware and software capable of spatially multiplexing and de-multiplexing multiple mmW signals. - Evaluate mmW spatial multiplexing approaches to distances at or beyond the Rayleigh Range.			
Title: Mobile Hotspots	17.100	17.678	13.650

Description: Communications requirements are growing exponentially due to the proliferation of high-data rate sensors (full motion video), Unmanned Aerial Vehicles (UAVs), and the emergence of the Soldier/Marine as both an operator and a sensor within military networks. However, limited spectrum availability results in a large disparity between capacity requirement and availability. Supporting the development of Advanced Networks technologies, Mobile Hotspots will develop an airborne high capacity data distribution network to interconnect groups of tactical users in a manner that is conceptually similar to the commercial tiered approach of interconnecting cell towers and wireless hotspots. Mobile Hotspots will exploit advances in millimeter-wave technology and airborne networking to develop a self-organizing, 1 Gbps mobility tactical airborne network formed from highly-directional communications links to interconnect mounted and dismounted warfighters, dispersed tactical operations centers, and intelligence, surveillance, and reconnaissance (ISR) assets. Low size, weight, and power (SWaP) designs will be integrated with commercial and military communications equipment and mounted on tactical UAVs and ground vehicles to provide network access to mobile users via infrastructureless hotspots that are compatible with existing radios. The Mobile Hotspots program is targeted to transition to the Army and Marine Corps Expeditionary Forces.

FY 2013 Accomplishments:
- Explored steerable antenna concepts, self-organizing network protocols, and efficient power amplifier implementations in a network topology to include UAVs, dismounted soldiers, and mobile platforms.
- Explored variable data rates, signal processing, and ad-hoc networking as a means to achieve range extensions in varying conditions.
- Evaluated capabilities of critical technologies in ground-based laboratory and field evaluations.
- Conducted system design trades for integration into a UAV pod and onto a tactical ground vehicle.

FY 2014 Plans:
- Manufacture antenna, amplifier, modem, and networking hardware needed to implement a self-organizing network comprising at least five hotspot nodes interconnected by 1 gigabit per second point-to-point millimeter-wave links to form a tactical airborne network.
- Integrate the Mobile Hotspots technology into pods for mounting on UAVs and tactical ground vehicles.
- Evaluate initial capabilities of the Mobile Hotspot prototype network and millimeter-wave tactical airborne network in an initial ground-based field experiment.
- Identify and implement system and subsystem improvements in preparation for final field experimentation and flight tests.

FY 2015 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Conduct ground testing of integrated air and ground vehicle systems to validate system operation and performance. - Conduct flight tests to evaluate system performance in various air-to-air, air-to-ground, and multi-node networking configurations.			
Title: Content-Based Mobile Edge Networking (CBMEN) ***Description:*** The CBMEN program's goal is to provide tactical warfighters operating at the edge with interactive, on-demand access to relevant information and a greater ability for real-time sharing of new operational content. This content can include images, video, maps, situational awareness, and command and control information. Advances in communications technologies are enabling high-capacity communications in remote environments. However, the current centralized or regional storage and dissemination of information presents reliability and capacity challenges with distributing relevant information to users at the edge. Commercial industry has developed approaches to the autonomous dissemination of high demand information by using distributed servers and advanced networking and information database technologies, combined with highly-reliable fixed networking infrastructure that have embedded complex information exploitation tools. The commercial system is enabled by infrastructure that is not available to the warfighter. This Advanced Networks technologies program will leverage commercial technologies to develop, prototype, and demonstrate the networking technologies and information dissemination techniques needed to enable efficient and robust content distribution using dynamic, mobile, and ad hoc military networks. CBMEN will be installed and demonstrated on existing radios. Capabilities from this effort will transition to the DoD. ***FY 2013 Accomplishments:*** - Developed extended small unit scenarios for simulation and demonstration. - Extended CBMEN software architecture for security and efficiency. - Integrated hardware and software products to demonstrate CBMEN technologies in small unit scenario. - Demonstrated limited content applications in a dynamic small unit mobile environment. ***FY 2014 Plans:*** - Develop objective metrics for advanced scenarios and simulation development for program evaluation and analysis. - Develop representative military small unit scenarios for simulations, over-the-air testing, demonstration, and transition. - Demonstrate CBMEN software for content naming, distribution, management, and security in a dynamic mobile environment. - Begin advanced development of CBMEN enabling technologies with increased scale, dynamics, and content rich applications.	19.732	13.510	-
Title: Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS) ***Description:*** The Wireless Network after Next (WNaN) and Advanced Wireless Networks for the Soldier (AWNS) program goals are to develop and demonstrate Advanced Networks technologies and system concepts that will enable densely deployed radio networks to compensate for limitations of the physical layer of a low-cost wireless node. WNaN/AWNS networks will manage node configurations and the topology of the network to reduce the demands on the physical and link layers of the network. The	15.565	7.500	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
technology created by the WNaN/AWNS effort will provide reliable and available battlefield communications at low system cost. AWNS also investigated the integration of Multi-User Detection (MUD) and Multiple-Input Multiple Output (MIMO) technology into the WNaN radio platform to position these technologies for transition into the WNaN radio node, as well as the Soldier Radio waveform (SRW) Anti-Jam (AJ) mode waveform. In addition, this effort investigated Wireless Distributive Computing (WDC), Content Based Access (CBA), and smart antenna technologies to enhance the network and node ability to understand the operating environment, mission concept of operations, and node responsibilities to assist in data processing, information dissemination, and accomplishment of military mission objectives. Further, this program will develop a low-cost handheld/body wearable wireless node that can be used to form high-density ad hoc networks and gateways to the Global Information Grid. This program will also develop robust networking architecture(s) and network technologies/processes that will exploit high-density node configurations. AWNS technology is planned for transition to the Services. ***FY 2013 Accomplishments:*** - Integrated smart antenna capabilities with radio nodes. - Demonstrated capability to integrate additional applications in an integrated network environment. - Integrated MIMO, WDC, advanced Dynamic Spectrum Awareness, and related technologies into the network capabilities to improve network performance, and increase network scalability without increasing spectrum need. - Commenced network integration evaluations, planning and execution of multiple field experiments with Marine Corps, Army, and Air Force to establish feasibility and utility for transition. - Performed design changes to hardware and software for enhanced stability. ***FY 2014 Plans:*** - Complete demonstration of network scaling to support company-level utility and scalability to large numbers of nodes. - Complete network integration evaluations and field experiments with Marine Corps, Army, and Air Force to establish feasibility and utility for transition.			
Title: Wireless Network Defense ***Description:*** * Formerly Highly Networked Force A highly networked and enabled force increases efficiency, effectiveness, and safety by making relevant information available when it is needed and at the appropriate location (person/platform/system). Accomplishing this depends on providing reliable wireless communications to all U.S. forces, platforms, and devices in all phases of conflict. Based on initial work under this effort, the Spectrum Efficiency and Access program in this PE/Project was created to enable reliable operation of military and commercial communications and radar systems when occupying the same spectrum bands. As part of the Advanced Networks technologies effort, the Wireless Network Defense program increases wireless network capacity and reliability for tactical users, with the ultimate vision of making high quality data services pervasive throughout the DoD. The primary focus is mitigation of	6.000	12.000	13.880

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
advanced threats particular to the security of wireless networks. The program intends to leverage the capabilities of the dynamic network to identify sources of misinformation, whether malicious or due to poor configuration, across the functional components of the complex system, and mitigate the corresponding effects. Technologies developed under this program will transition to the Services. ***FY 2013 Accomplishments:*** - Investigated techniques to determine the integrity of communications nodes and sub networks from both physical, network, and application-based information. - Investigated new routing, naming, and networking mechanisms optimized for addressing network outages and security needs. ***FY 2014 Plans:*** - Develop techniques to characterize reliability of information in networks with misbehaving devices and evaluate performance through simulation. - Develop approaches to adapt the control functions of wireless networks to accept reliability values and create innately resilient control systems. - Determine system-level performance goals for subsequent phase of the program. - Begin integration of most promising technology components for reliability estimation and robust network control into laboratory prototypes of robust wireless networks. ***FY 2015 Plans:*** - Complete integration of candidate algorithms and protocols for protecting networks from, and detecting and reacting to, misinformation attacks in laboratory-based prototype systems. - Test resilience of prototype capabilities in a laboratory environment. - Refine protection mechanisms based on test findings and begin development of systems for field demonstrations.			
Title: Spectrum Efficiency and Access ***Description:*** Current Presidential Initiatives, FCC Broadband Task Force, and Congressional legislation are working to transition large swaths of spectrum (up to 500 MHz) from Federal (DoD is the primary contributor) to civilian use for broadband telecommunications. The DoD will need more highly-integrated and networked data/sensor capacity over the next decades and will therefore need new technology that requires less spectrum to operate. The objective of the Spectrum Efficiency and Access program is to investigate improvements in spectral reuse, such as spectrum sharing of sensor/radar bands. The program will leverage technical trends in cooperative sharing to exploit radar anti-jam and interference mitigation technologies that could enable spectrum sharing by allowing overlay of communications within the same spectral footprint. The approach will include exploring real-time control data links between radars and communications systems, and developing the advanced waveforms and components to enable radars and communication networks to operate in close proximity. The ultimate goal is to turn the DoD	-	8.400	19.971

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
spectrum loss into a net gain of up to hundreds of MHz in capacity. Technology from this program will be made available to the DoD. ***FY 2014 Plans:*** - Develop concepts and management policies for enabling radars and communications networks to share spectrum spatially and temporally. - Develop models and simulation capability for research on spectrum sharing between radar and communications systems. - Assess the limits on achievable spectral reuse between radar and communications in order to evaluate sharing concepts and implementations. - Assess threats to military systems created by sharing spectrum information with non-military users. ***FY 2015 Plans:*** - Model and assess multiple mechanisms for spatial and temporal spectrum sharing between radars and communications networks. - Develop and assess a baseline set of strategies to defend military systems against threats created by sharing spectrum information between military radars and commercial communications systems. - Develop concepts for a control system to manage mechanisms for spectrum sharing between radars and communication systems. - Demonstrate technologies for signal separation between radar and communications systems operating at the same time, place, and frequency. - Develop concepts and approaches for a joint system design between military radar and military communications systems operating in a shared spectrum allocation that improves overall performance in electronic countermeasure operating environments.			
Title: Advanced RF Mapping ***Description:*** One of the key advantages on the battlefield is the ability to actively sense and manipulate the radio frequency (RF) environment, enabling reliable and assured communications, as well as effectively mapping and manipulating the adversary's communications in ways that defy their situational awareness, understanding, or response. Current approaches are emitter-based, with the signal processing techniques focused on array and time-based processing for each emitter. As the RF environment becomes more complex and cluttered, the number of collection assets and the required level of signal processing inhibits our capability to pervasively sense and manipulate at the precision (time, frequency, and space) required for effective action. To address these Radio Frequency and Spectral Sensing (RF/SS) challenges, the Advanced RF Mapping program will develop and demonstrate new concepts for sensing and manipulating the RF environment based on distributed rather than centralized collection. This approach will take advantage of the proliferation of RF devices, such as radios and cell phones, on the battlefield. To leverage these existing devices effectively, the program will develop new algorithms that can map the RF	10.300	19.500	17.762

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
environment with minimal communication load between devices. It will also develop approaches to exploit our precise knowledge of the RF environment and the distributed proximity of RF devices to provide reliable and assured communications for our warfighter as well as to infiltrate or negate our adversaries' communications networks. Building upon technologies investigated within other programs within this project, the Advanced RF Mapping program will enable both offensive and defensive operations in complex RF environments. Advanced RF Mapping technology is planned to transition to the Services. ***FY 2013 Accomplishments:*** - Established baseline capabilities for RF collection from distributed devices in complex RF environments. - Initiated the development of algorithms to exploit distributed RF collections and to produce a full environmental map of frequency and space as a function of time. - Assessed approaches to exploit RF environment knowledge and distributed RF devices to provide new capabilities to assess adversary networks and defend against hostile use of the RF spectrum. ***FY 2014 Plans:*** - Develop and deploy prototype networks employing multiple types of RF devices of different types for experimentation with the RF mapping technology. - Demonstrate RF mapping capability to characterize RF signals in tactically relevant VHF and UHF frequency bands, using a limited number of distributed devices while minimizing communications requirements between devices. - Determine the performance improvement for signal detection and identification of RF mapping systems over tactically relevant collection times. - Improve RF collection capabilities to cover low-rate tactical networks and limited device availability in tactical environments. - Establish baseline capability for defending against hostile use of the RF spectrum. ***FY 2015 Plans:*** - Carry out field experiments that demonstrate use of currently deployed tactical radios as sensors within a heterogeneous RF mapping network. - Develop a software layer that simplifies addition of new capabilities to the heterogeneous RF mapping network after it has been fielded. - Demonstrate improved battlefield spectrum planning and spectrum management operations through feedback of spectrum utilization information from RF sensors. - Develop a command and control system for optimizing use of devices as RF sensors in a changing operational environment. - Develop and demonstrate geo-location capability of RF emitters using the heterogeneous RF mapping network.			
Title: Computational Leverage Against Surveillance Systems (CLASS)	11.750	28.325	22.600

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Description: Commercial Test and Measurement equipment has advanced greatly with the emergence of sophisticated cellular and wireless local area network technology and can be used to intercept, analyze, and exploit our military communications signals. The Computational Leverage Against Surveillance Systems (CLASS) program, working to expand Low Probability of Detection/Anti-Jam (LPD)/(AJ) technologies, seeks new ways to protect our signals from exploitation by increasingly sophisticated adversaries, in ways that can be maintained as commercial technology advances. Three different techniques are in development: 1) Waveform Complexity uses advanced communications waveforms that are difficult to recover without knowledge and understanding of the signals itself; 2) Spatial Diversity uses distributed communications devices and the communication environment to disguise and dynamically vary the apparent location of the signal; and 3) Interference Exploitation makes use of the clutter in the signal environment to make it difficult for an adversary to isolate a particular signal. The program's objective is to make modular communications technology that is inexpensive to incorporate in existing and emerging radio systems (<$100 incremental cost) but pushes adversaries to need more than 1,000x our processing power - supercomputer-level processing power. Another track of the program will extend the CLASS technology to provide LPD communications. These techniques will drastically reduce the detectability of communications signals beyond current capabilities. Scalable performance will allow LPD techniques to better trade information rate for communications capacity. Technologies from this program are planned to transition to the Services.			
FY 2013 Accomplishments: - Integrated hardware and firmware technology into volume integrated circuits. - Developed test and application driver software for CLASS technology. - Initiated development of modular CLASS products. - Developed LDP signaling techniques.			
FY 2014 Plans: - Develop operational concepts for distributed airborne operations. - Conduct RF transceiver studies for airborne operations. - Finalize design of CLASS RF and modem integrated circuits; release to foundry for fabrication. - Integrate application driver software for CLASS technology in preparation for Application Specific Integrated Circuits (ASIC) testing. - Produce modular CLASS products and develop board for ASIC testing and a radio product module. - Leverage advancements towards an alternative development environment for communications systems that takes advantage of commercial smartphone development environment methodology. - Develop an alternative generalized reference architecture that supports communications system integration specifically, and that supports future revisions for other electronic systems anticipated in airborne force projection systems.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Investigate and cost candidate satellite constellation configurations to quantify the trade-off between space segment cost and system coverage and capacity. - Investigate techniques to collaborate among distributed transmitters and receivers for the geometries of beyond line-of-sight solutions (such as airborne and/or space layers), and quantify expected performance relative to predicted system threats. ***FY 2015 Plans:*** - Develop concepts for integrating CLASS technologies with aircraft antennas and communications equipment. - Measure CLASS modem performance processing power, power consumption, and radio waveform interoperability. - Integrate CLASS modular technology with host processor. - Demonstrate CLASS communication capability with and without interference against Army threat intercept surrogates. - Develop Emulation environment for the reference architecture; test and publish emulation models. - Publish Beta version of the development environment to a third party service user for evaluation testing. - Measure CLASS modem transmit power reduction as number of cooperative transmitters is increased from 1 to 8.			
Title: Communication in Contested Environments ***Description:*** Building upon the technologies explored and developed under the Computational Leverage Against Surveillance Systems (CLASS) program budgeted in this PE/Project, the Communication in Contested Environments program will seek to address communications problems anticipated in networked airborne systems in the mid-21st century. Expected growth in sensor systems, unmanned systems, and internetworked weapons systems will strain the size of networks that our current communications technology can support in the contested environment. As adversary capabilities advance, the DoD will need new techniques to quickly and efficiently accommodate better networking and improved communications capabilities, specifically communications systems with higher capacity, lower latency, greater jamming resistance, and reduced detectability. As part of Advanced Networks technologies efforts, the Communication in Contested Environments (C2E) program addresses these needs with a three-pronged approach: first, to develop heterogeneous networking capabilities and advanced communication technology for airborne systems. Anti-jam, Low Probability of Detection (LPD), low latency, and high capacity communication protocols will be developed. Second, to create a government controlled and maintained reference architecture for communications systems that draws from commercial communication architectures. The defense contractor community can build specific communications systems based upon this reference architecture. Finally, to create a government controlled development environment to allow rapid refresh of communications technology and allow third party native application and waveform developers to contribute their own communications technologies. ***FY 2014 Plans:*** - Create initial version of a development environment for military communications applications and waveforms similar to the development environments used in the commercial smartphone market.	-	2.000	13.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Develop an initial reference architecture to support interoperable communications and heterogeneous networking. ***FY 2015 Plans:*** - Build a communications reference hardware system to support L-band and microwave communications. - Compile waveforms for the reference hardware. - Build infrastructure networking automation layer for link establishment, maintenance, and service prioritization. - Test infrastructure networking code to the reference system and evaluate pervasive networking performance.			
Title: Assured Beyond Line-of-Sight Communications ***Description:*** In areas where near-peer adversaries have denied effective U.S. operations, our current systems are unable to provide sufficient communications capabilities. In support of Low Probability of Detection Anti-Jam (LPD/AJ) technologies, the Assured Beyond Line-of-Sight Communications program seeks to provide the capability by which platforms can operate undetectably in denied areas while maintaining sufficient communications with assets outside the anti-access region. Necessary system attributes include low probability of detection or exploitation, jam-resistance, and costs that reverse the imbalance of kinetic threats. In addition, sufficient capacity to enable command and control of advanced weapons systems and communication of advanced intelligence, surveillance, and reconnaissance (ISR) artifacts are necessary. The program will leverage advances from programs such as Computational Leverage Against Surveillance Systems (CLASS) in distributed, collaborative communications to reduce transmitter powers and increase system data rates and interference resistance for the required communication ranges. Technology developed under this program will be transitioned to the Air Force, Navy, Marine Corps, and Army. ***FY 2015 Plans:*** - Develop candidate system designs, including system architecture, payload design, and ground segment component requirements. - Develop communication signaling designs and associated performance analysis for widely separated collaborative transmitters and receivers for the candidate architectures. - Begin development of hardware prototypes and integrate signal processing in preparation for testing communication system capabilities.	-	-	10.000
Title: Millimeter-wave Frequencies Transceiver ***Description:*** Military radars, communications systems, and signal intelligence equipment are expanding into the millimeter-wave portion of the spectrum to ease congestion, leverage available bandwidth, and for the low probability of detection, low probability of intercept, and anti-jam capabilities. Millimeter-wave signals are often challenging to detect, analyze, and exploit with low latency using state-of-the-art digital receivers and signal processors. Effective protection against these systems requires receiver and signal processing technologies that provide high sensitivity, high dynamic range, and low latency and interference resilience.	-	-	8.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
However, existing millimeter-wave receiver and signal processing capabilities lack the needed performance characteristics to address advanced threats. This program builds upon other millimeter-wave communications technologies developed under this PE/Project and seeks to develop a transceiver that is capable of operating at millimeter-wave frequencies with high sensitivity and high dynamic range and processing signals with wide bandwidths. The program will leverage the inherent broadband, high dynamic range, and low latency characteristics of photonic processing components to develop system prototypes for addressing adversary millimeter-wave communications and radar systems. Technologies developed under this program will transition to the Navy and Air Force. ***FY 2015 Plans:*** - Identify promising approaches to efficiently couple incoming microwave signals to the electro-optic modulators. - Identify candidate photonic link architectures that achieve low noise figure, high dynamic range, and high receiver sensitivity. - Identify candidate photonic circuit architectures that characterize the amplitude, frequency, phase, or time of a millimeter-wave signal. - Identify candidate interference signals, including low power, high power, continuous, pulsed, narrowband, and broadband signals that will be used to evaluate the sensitivity and resilience of the photonically enabled systems. - Develop field test plans that will be used to characterize the photonically enabled systems in the presence of interfering signals.			
Title: Communications Under Extreme RF Spectrum Conditions (CommEx)	13.265	12.500	-
Description: The Communications Under Extreme RF Spectrum Conditions (CommEx) program will develop signal detection and reasoning technology that will allow radios to recognize interference and jamming attacks and then adapt to maintain communications, even in the presence of cognitive jammer attacks and dynamic interference of multiple cognitive network interactions. As part of Low Probability of Detection/Anti-Jam (LPD/AJ) technologies efforts in the Project, the program will develop models of adversary, commercial, and friendly cognitive radios and implement those models to assess, in real time, the current and future dynamics of the communications network. Core technologies for operation in highly dynamic and/or high jamming to signal environments will be developed to include: automated jamming waveform forensics; local environment assessment (time, space, frequency, polarization); technologies for addressing known attack strategies and interference properties; and antenna, signal processing, modulation, and network optimization technologies. Based on predictions of the level of communication success compared to mission communication requirements, the cognitive radio will choose waveform selections/configurations that best achieve mission objectives. The cognitive radio will include the capability to analyze and select optimum frequency, waveform, and network configurations during all aspects of a mission. The design effort will lead to new radio communication architectures, more robust radio communication networking, and better understanding of selection amongst interference avoidance and interference suppression strategies. This program also seeks to enable communication between dispersed and distributed emitters and receivers to provide a multiplier in capacity for both locating emitters and assessing			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
effectiveness of an electronic attack. Technologies developed in this program will transition to the Army, Navy, Air Force, and Marines. ***FY 2013 Accomplishments:*** - Performed third cycle of government performance evaluation for computer model simulations of spectrum analysis, reasoning about interference mitigation choices, interference mitigation, and reasoning update logic. - Executed designs of system technologies to address the specific application(s) and platform(s) required for military operations. - Performed laboratory experiments utilizing unknown attack strategies to validate developed mitigation techniques. - Completed system design that addresses technology insertion within size, weight, and power constraints. - Utilized properties and limitations of existing jammer technologies to assess performance. - Demonstrated the ability to learn and rapidly recognize behavior patterns of various types of attacks against advanced radios. - Performed laboratory experiments with brassboard and realistic communication systems to validate performance. - Initiated prototyping of CommEx technologies in Link 16 and Wireless Network after Next (WNaN) system hardware for utilization in airborne and vehicular use. - Demonstrated and measured a high level of co-site suppression on real time hardware on Frequency Shift Keying (FSK) waveforms using the same frequency and bandwidth. ***FY 2014 Plans:*** - Validate the size, weight, power, cost (SWaP-C), and network overhead of systems that implement the principles developed in this program. - Develop detailed technology and algorithms into specific hardware and platforms to assure that implementation specifics can be integrated into communication systems. - Develop architecture to allow CommEx technology to be inserted into assessment platforms for military utility. - Conduct study to evaluate the application of CommEx principles on existing military systems. - Conduct field evaluations and demonstrations on airborne and ground platforms to determine military utility.			
Accomplishments/Planned Programs Subtotals	104.901	152.913	135.633

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-02 / *INFORMATION INTEGRATION SYSTEMS*

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 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-04 / *SECURE INFORMATION AND NETWORK 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
CCC-04: *SECURE INFORMATION AND NETWORK SYSTEMS*	-	16.833	10.120	2.707	-	2.707	-	-	-	-	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Rapid Software Development using Binary Components (RAPID)	13.133	10.120	2.707

Description: The Rapid Software Development using Binary Components (RAPID) program will develop a system to identify and extract software components for reuse in new applications. The DoD has critical applications that must be ported to future operating systems. In many cases, the application source code is no longer available requiring these applications to continue to run on insecure and out-dated operating systems, impacting operations. A companion applied research effort is budgeted in PE 0602303E, Project IT-03. RAPID capabilities will transition to the Services.

FY 2013 Accomplishments:
- Developed an end-to-end proof-of-concept system showing identification, extraction, and combination of components into new executables.
- Demonstrated scalable performance by extracting, assembling, and generating executables from a large number of components.

FY 2014 Plans:
- Demonstrate the system to military users and conduct transition planning.
- Participate in technology evaluation exercises with military stakeholders.
- Support transition partners in developing a software reuse concept of operations.

FY 2015 Plans:

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-04 / *SECURE INFORMATION AND NETWORK SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Deploy prototype systems at transition partner sites and support initial operations.			
Title: Cyber Insider Threat (CINDER)	3.700	-	-
Description: The Cyber Insider Threat (CINDER) program developed technologies for identifying advanced cyber threat missions that may be currently ongoing within DoD and government interest systems and networks. Current cyber defenses are primarily based on network and host intrusion detection and look for break-ins and abnormal behavior without context. The CINDER program built tools and techniques that applied mission templates of advanced cyber espionage onto seemingly normal internal system and network activity. The program focused on identifying ongoing adversary missions rather than a person, program, or particular piece of malware. Through this CINDER uncovered ongoing advanced persistent cyber threats and espionage within our cyber environments. Capabilities from this program transitioned to DoD and the defense industrial base. ***FY 2013 Accomplishments:*** - Transitioned advanced network scanning software for detecting insider data compromises to numerous government and commercial entities as open source software with over 3 million downloads to date. - Developed a system to analyze crash artifacts to provide insight into novel attacks, gauge the capabilities of adversaries, and understand attacker goals and intentions. - Developed a system for detecting and countering the threat to source code repositories posed by malicious insider access, tampering, and exfiltration. - Developed a system for detecting malicious cyber insiders using a lightweight embedding technique on existing web applications, including a lightweight collection module, a detection point toolkit, an analysis server, and a management graphical user interface.			
Accomplishments/Planned Programs Subtotals	16.833	10.120	2.707

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 / 3	**R-1 Program Element (Number/Name)** PE 0603760E / *COMMAND, CONTROL AND COMMUNICATIONS SYSTEMS*	**Project (Number/Name)** CCC-06 / *COMMAND, CONTRO AND COMMUNICATION 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
CCC-06: *COMMAND, CONTRO AND COMMUNICATION SYSTEMS*	-	56.733	76.045	104.925	-	104.925	86.070	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

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Classified DARPA Program	56.733	76.045	104.925
Description: This project funds Classified DARPA Programs. Details of this submission are classified.			
FY 2013 Accomplishments: Details will be provided under separate cover.			
FY 2014 Plans: Details will be provided under separate cover.			
FY 2015 Plans: Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	56.733	76.045	104.925

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603765E / *CLASSIFIED DARPA PROGRAMS*

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	-	2.760	-	-	-	-	-	-	-	-	-	-
CLP-01: *CLASSIFIED DARPA PROGRAMS*	-	2.760	-	-	-	-	-	-	-	-	-	-

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

A. Mission Description and Budget Item Justification

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

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	3.000	-	-	-	-
Current President's Budget	2.760	-	-	-	-
Total Adjustments	-0.240	-	-	-	-
• Congressional General Reductions	-0.004	-			
• Congressional Directed Reductions	-0.190	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.046	-			

Change Summary Explanation

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

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Classified DARPA Programs	2.760	-	-
Description: Classified DARPA Programs			
FY 2013 Accomplishments: Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	2.760	-	-

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 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603765E / *CLASSIFIED DARPA PROGRAMS*

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC 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
Total Program Element	-	221.490	259.006	386.926	-	386.926	390.744	356.083	318.096	294.181	-	-
NET-01: *JOINT WARFARE SYSTEMS*	-	69.610	36.745	63.144	-	63.144	82.067	94.266	134.741	150.029	-	-
NET-02: *MARITIME SYSTEMS*	-	41.464	50.853	80.882	-	80.882	100.877	117.817	140.355	144.152	-	-
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	110.416	171.408	242.900	-	242.900	207.800	144.000	43.000	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	236.883	259.006	258.106	-	258.106
Current President's Budget	221.490	259.006	386.926	-	386.926
Total Adjustments	-15.393	-	128.820	-	128.820
• Congressional General Reductions	-0.309	-			
• Congressional Directed Reductions	-24.925	-			
• Congressional Rescissions	-	-			
• Congressional Adds	7.500	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	8.515	-			
• SBIR/STTR Transfer	-6.174	-			
• TotalOtherAdjustments	-	-	128.820	-	128.820

Change Summary Explanation

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

FY 2015: Increase reflects new efforts for a system of systems architecture, technical development and demonstration program, expanded maritime efforts, and an increase in classified programs.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE 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
NET-01: *JOINT WARFARE SYSTEMS*	-	69.610	36.745	63.144	-	63.144	82.067	94.266	134.741	150.029	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: High Energy Liquid Laser Area Defense System (HELLADS)	41.641	25.045	24.144
Description: This program builds upon the past achievements of the High Energy Liquid Laser Area Defense System (HELLADS) development program and the Aero-Adaptive Aero-Optic Beam Control (ABC) program that were budgeted in DARPA PE 0602702E, Project TT-06. The goal of the HELLADS program is to develop a high-energy laser weapon system that will provide an order of magnitude reduction in weight compared to existing laser systems. HELLADS will enable high-energy lasers (HELs) to be integrated onto tactical aircraft and will significantly increase engagement ranges compared to ground-based systems, in addition to enabling high precision/low collateral damage and rapid engagement of fleeting targets for both offensive and defensive missions. Advancements in beam control and other subsystems that are required for the practical integration of a laser weapon into existing tactical platforms will be explored. With the assistance of the Services, the HELLADS program will pursue the necessary analysis, coordination, and design activity for a prototype laser weapon system incorporating the HELLADS laser system and the ABC turret into air-, ground-, or sea-based tactical vehicles. While the prototype laser weapon system module is in design and development, the HELLADS 150 kilowatt (kW) laser will be made available for demonstration opportunities and transition to the Army, Navy, or Air Force.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Continued risk reduction tests of tracking systems for dynamic targets, demonstrated aim point accuracy to support lethal power delivery to test targets in representative battlefield environments. - Completed laboratory checkout and government acceptance of 150 kW laser module; packaged laser and shipped for integration into the high power laser demonstrator system. - Completed high power optics insertion, safety system check-outs, range communications protocol check, and initial high power static operation of laser weapon demonstrator to verify that the laser and its subsystems can safely demonstrate lethal effects on mortars and rockets. - Completed system requirements review of broad utility laser weapon module subsystems including integrating structure, platform interfaces, beam control, and battle management subsystems for integration on air-, ground-, or sea-based tactical vehicles. - Initiated preliminary design phase of laser weapon system module prototype for tri-Service employment. - Completed the fabrication of the 150 kW laser and started field test system integration. - Completed 150 kW laser integration and subsystem testing of the ground-based demonstrator laser weapon system. - Developed novel beam control alternative concepts designed to enhance lethal power delivery to target through severe atmospheric turbulence. ***FY 2014 Plans:*** - Complete live fire tests against rocket and mortar fly-outs to demonstrate lethal laser power at mission-relevant ranges. - Transport demonstrator laser from Army mission (rocket/mortar) relevant ground test site to mountain peak test site to mimic Air Force missions for precision air-to-ground and airborne self-defense demonstrations. - Prosecute live fire targets from mountain peak test site to demonstrate performance of laser weapon system in airborne missions to include targeting of ground vehicles and self-defense against surface to air missiles. - Complete preliminary design and detailed design of laser weapon module prototype's subsystems for integration on a specific air-, ground-, or sea-based tactical vehicle. - Plan for fabrication of the laser weapons system module prototype tailored for the selected Service environment (air, ground, or sea) tactical platform. - Initiate preparations for field testing of prototype against the appropriate target set on the selected Service platform. ***FY 2015 Plans:*** - Conclude live fire target prosecution from mountain peak test site to demonstrate performance of laser weapon system in airborne missions, to include targeting of ground vehicles and self-defense against surface to air missiles. - Commence fabrication of the laser weapons system module prototype in collaboration with selected Service partners. - Refurbish field test 150 kW laser and ready for installation into prototype laser weapon system module.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Integrate laser and support subsystems to ready prototype laser weapon system module for field testing.			
Title: Legged Squad Support System (LS3) ***Description:*** The Legged Squad Support System (LS3) program will explore the development of a mission-relevant quadruped platform scaled to unburden the infantry squad and hence unburden the soldier. In current operations, soldiers carry upwards of 50lbs of equipment, in some cases over 100lbs, over long distances in terrain not always accessible by wheeled platforms that support infantry. As a result, the soldier's combat effectiveness can be compromised. The LS3 program will design and develop prototypes capable of carrying 400lbs of payload for 20 miles in 24 hours, negotiating terrain at endurance levels expected of typical squad maneuvers. LS3 will leverage technical breakthroughs of prior biologically inspired legged platform development efforts. It will develop system designs to the scale and performance adequate for infantry squad mission applications, focusing on platform, control, and human-machine interaction capabilities, as well as secondary design considerations, such as acoustic signature. Anticipated service users include the Army, Marines, and Special Forces. ***FY 2013 Accomplishments:*** - Completed build of prototype systems resulting in two standard systems and one that utilizes a heavy fueled engine option. - Performed experiments to assess the mobility and perception capabilities of the platform from a technology standpoint. - Began technical and operational assessments with the U.S. Marine Corps to evaluate the abilities of the LS3 platform within mission objectives as applied to the LS3 mission profile. ***FY 2014 Plans:*** - Support and refine system prototypes as necessary. - Design and build additional LS3 prototype to address novel approaches to energy consumption, increased survivability and reduced noise. - Participate in final demonstration activities in coordination with the U.S. Marine Corps. - Complete production of final LS3 prototype addressing enhancements to system reliability, energy consumption, survivability and noise reduction. - Conduct endurance, reliability, survivability and signature (noise reduction) testing of final LS3 system.	13.331	3.000	-
Title: Robotics Challenge ***Description:*** Advancements are being made in land-capable, high degree-of-freedom unmanned platforms to enable mobility over complex terrain. Many current prototypes are inspired by biological systems and while proof-of-principle systems have or are demonstrating unprecedented mobility, limitations have emerged. Advanced capabilities in perception, control, and physical capability/coordination are needed to work autonomously in human environments. These are critical enablers for performing mission-relevant tasks in austere and remote regions, partially-destroyed roads, high-threat anti-access/area denied environments, rubble-filled areas, and providing greater range/endurance for soldiers, platforms, and personnel.	14.638	8.700	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
The Robotics Challenge program will boost innovation in autonomous systems and expand platform utility through enhanced actuation, energy density, perception, locomotion, agile reconfiguration, and design efficiency. Program thrusts are centered on a progressive regimen of physical problem solving, real-time team oriented tasks, and dynamic adaptation designed to build "machine trust", especially when integrated with humans in a variety of operational environments. The Robotics Challenge program consists of a series of obstacle course style challenge events that will focus on technology solutions to demonstrate and test robot capabilities for disaster response. Robotics Challenge events will drive advances in power systems, agility and speed, precision in perception tied to platform coordination, dexterity, and impulsive power. Program objectives focus on technologies to expand mobility and extend endurance of unmanned platforms, advanced tactile and manipulation capabilities, and tools for cost effective design, validation, and construction of autonomous technology, and human-robot interaction. The 6.2 portion of this program is budgeted in PE 0602702E Project TT-04. Anticipated Service users include the Army, Marines, and Special Forces. ***FY 2013 Accomplishments:*** - Completed development of humanoid robot platform for algorithm testing during DARPA Robotics Challenge Trials. - Developed and validated robot simulation system. ***FY 2014 Plans:*** - Coordinate Service participation in Robotics Challenge and apply simulation system to Service areas of interest. - Conduct DARPA Robotics Challenge Trials. - Extrapolate on and conduct further modeling and simulation of techniques and approaches for application to a larger system of systems applications.			
Title: Integrated Planning for Strike, ISR, and Spectrum (IPSIS) ***Description:*** To counter peer threats, the military is increasingly turning to networked weapons and sensors on-board a heterogeneous mix of multi-purpose manned and unmanned systems. Traditionally, Command and Control (C2) systems and planning have operated independently across domains and are optimized for a permissive environment where communications are assured. However, to address the challenges faced in today's increasingly contested environments, the Integrated Planning for Strike, ISR, and Spectrum Planning (IPSIS) program will develop tools to tightly synchronize strike, Intelligence Surveillance and Reconnaissance (ISR), and communications spectrum management planning and maximize the contribution of all assets through increased utilization, exploiting synergies, and defending against network disruption. The program will develop tools supporting a mixed initiative planning approach, maximizing automation according to operator's choice, and enabling human-in-the-loop intervention and modification. The tools will provide a decomposition of the commander's intent into targeting and information needs, and develop plans to satisfy the identified synchronization needs across multiple domains. During execution, the tools will provide lifecycle tracking of targeting and information needs and sophisticated plans, and real-time execution visualization capabilities. The tools will dynamically respond as directed to ad hoc requests and significant plan deviations via a	-	-	12.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
real-time dynamic re-planning capability, and easily adapt to technology refreshes. The IPSIS tools will transition to the Air Force and the Navy. ***FY 2015 Plans:*** - Develop concept of operations for an integrated strike, ISR, and spectrum management capability operating in an Air Operations Center and/or Maritime Operations Center. - Develop system architecture for integrated strike, ISR, and spectrum management to include planning, assessment, and dynamic replanning. - Develop models and simulation capability for test, analysis, and validation of integrated planning capability. - Develop a plan representation for integrated strike, ISR, and spectrum planning. - Develop algorithms for the decomposition of commander's intent and the construction of integration plans.			
Title: System of Systems Architecture, Technology Development, and Demonstration ***Description:*** The System of Systems Architecture, Technology Development, and Demonstration program seeks to implement an architecture framework capable of assessing and demonstrating potential operational benefits of integrating various system capabilities to improve mission success in contested environments. Such assessments would optimize system-level trades of requirements and architectures to properly leverage an integrated set of system characteristics and capabilities. The demonstration assessment metrics will measure individual and combined system performance to further streamline resource allocation to maximize operational impact. In addition, providing a modeling and simulation (M&S) environment to assess complex systems will enable greater utility of emerging system technologies, since they can be assessed in near-real-world simulations without the real-world costs of testing fully integrated systems. The program will also develop system synthesis and integration technologies that enable rapid assimilation of new and off-the-shelf technologies into the system of systems architecture. These technologies will break down current barriers to entry that new technologies face in system of systems using formal methods, compositional reasoning, and automated design space exploration. Technologies from this program will be transitioned to the Services. ***FY 2015 Plans:*** - Develop reference objective system of systems architecture. - Complete the architecture development and integration design. - Develop architecture demonstration plan, including range and platform options. - Implement M&S capabilities for architecture design analysis and validation. - Complete the development of system of systems synthesis and integration tools and protocols. - Commence development of engineering tools to validate system of system architecture designs.	-	-	16.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Commence development of formal verification techniques to validate integration of constituent systems into a system of systems.			
Title: Secure Distributed Dynamic Computing (SDDC)	-	-	11.000
Description: The Secure Distributed Dynamic Computing (SDDC) program will create distributed computing architectures for mobile military environments. Commercial computing services are enabled by massive data centers and high-capacity terrestrial networks, but this level of infrastructure is not available to forward-deployed military forces that operate in mobile, disrupted/disadvantaged, intermittent, high-latency environments. SDDC will make the cyber environment as maneuverable as the troops it supports by creating computing architectures that combine aspects of multi-computing and cloud computing with dynamic monitoring and adaptation of distributed computing environments. These maneuverable architectures will be cognizant of bandwidth-limited data links that operate in contested environments and lack quality-of-service guarantees. An additional requirement arises from the need to ensure access to critical data even when requisite data services are temporarily down or when the data is stored in a format that is no longer supported. An even more stressing case arises when the entire network goes down: restoring the network and reinitiating service to all users is an urgent requirement. SDDC technologies will automatically and dynamically adjust policies and allocate bandwidth, computational resources, and cyber-defense assets to provide reliable, energy-aware, large-scale data processing to forward-deployed tactical users, without dependence upon external non-military resources. ***FY 2015 Plans:*** - Develop distributed computing architectures for mobile, disrupted/disadvantaged, intermittent, high-latency military environments. - Create dynamic computing architectures suitable for use with bandwidth-limited data links that lack quality-of-service guarantees. - Develop techniques to automatically adjust policies and allocate available bandwidth and compute cycles to provide reliable, energy-aware, large-scale data processing.			
Accomplishments/Planned Programs Subtotals	69.610	36.745	63.144

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

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 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-02 / *MARITIME 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
NET-02: *MARITIME SYSTEMS*	-	41.464	50.853	80.882	-	80.882	100.877	117.817	140.355	144.152	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Distributed Agile Submarine Hunting (DASH)	30.464	28.943	8.474

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

FY 2013 Accomplishments:

- Demonstrated passive and active sonar prototypes scalable to large deep-ocean areas for wide area surveillance and maneuver warfare.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrated the ability to detect U.S. submarines with both passive and active sonar, showing scalability to detect the quietest of diesel-electric threat submarines. - Commenced testing of initial multi-node communication network for persistent connectivity from seafloor-to-shore. - Initiated planning for the demonstration of multi-node systems. - Completed non-acoustic signature discovery and assessment. ***FY 2014 Plans:*** - Complete development of deep sea prototypes system of distributed sonar nodes, both passive and active. - Complete development of distributed multi-node communication network for connectivity between seafloor, surface, and shore or ship. - Demonstrate extended remote monitoring capability of a passive sonar barrier network at sea. - Demonstrate Unmanned Undersea Vehicle (UUV)-based active sonar in a deep sea test showing target detection and tracking. - Integrate technologies for autonomous, reliable, and secure undersea energy and date transfers to fixed and mobile undersea systems. ***FY 2015 Plans:*** - Design and develop longer-duration passive and active sonar nodes. - Conduct extended-duration sonar demonstrations at sea against a target. - Demonstrate connectivity from seafloor node to remote shore station. - Integrate distributed communications with Navy systems for data transfer and Command, Control, Communications, Computers, and Intelligence (C4I). - Initiate test planning for passive and active sonar sea test.			
Title: Structural Logic ***Description:*** The Structural Logic program is developing platform structures and frames that can adapt to varying loads and simultaneously exhibit both high stiffness and high damping. This program will demonstrate the utility of negative stiffness structural elements developed under the Multifunctional Materials and Structures program, budgeted in PE 0602715E, Project MBT-01, in the ridged support frames of real world DoD platforms. As the demands on military platforms increase, so does the need for structures to mitigate the shock and vibrations applied by dynamic environments. Today's structures exhibit limited adaptability and typically achieve either extreme stiffness or damping. In military platforms, extremely stiff structures provide high strength, but readily transfer loads to passengers often resulting in serious injury. Conversely, existing damping structures can reduce the load transferred to passengers, but only at the expense of structural strength and integrity. By demonstrating the ability to combine stiffness, damping, and dynamic range in a single structure, the Structural Logic program will enable the design of military platforms with the ability to continually adapt their properties to match the demands of a dynamic environment. Technology from this program will transition to the Navy.	9.000	7.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Initiated the design and construction of a sub-scale high-speed planing boat structure that incorporates arrays of adaptive structural subassemblies made up of mechanical programs of tiered negative stiffness structural elements. ***FY 2014 Plans:*** - Complete construction of sub-scale high-speed planing boat incorporating negative stiffness elements; perform system testing and evaluation with Navy partners, demonstrating the technology in a realistic environment.			
Title: Hydra ***Description:*** The Hydra program will develop and demonstrate advanced capabilities for the undersea deployment and employment of unique payloads. Hydra integrates existing and emerging technologies and the ability to be positioned in the littoral undersea battlespace to create a disruptive capability. The system consists of a modular enclosure with communications, command and control, energy storage, and standard interfaces for payload systems. It will leverage concepts developed under the TEMP program, PE 0602702E, Project, TT-03. The modular enclosures are deployed by various means, depending on the need for speed and stealth and remain deployed until awakened for employment. Hydra will develop critical enabling technologies for energy storage and recharging, communications, command and control, deployment, and autonomous operations. Technologies from this program will transition to the Navy. ***FY 2014 Plans:*** - Conduct studies to refine the operational trade space, define limits of current technology, and develop new technical approaches. - Initiate concept designs for the modular enclosure and potential payloads. - Explore innovative approaches for key enabling technologies such as energy storage, communications, and deployment. - Conduct risk reduction of key enabling technologies. - Investigate deployment options and initiate system conceptual design. ***FY 2015 Plans:*** - Complete concept designs for the modular enclosure and potential payloads. - Begin development of a prototype modular enclosure. - Begin development of one or more potential payloads. - Demonstrate enabling technologies and subsystems.	-	14.910	29.898
Title: Hybrid Multi Material Rotor Full Scale Demonstration ***Description:*** The goal of the Hybrid Multi Material Rotor Full-Scale Demonstration (HyDem) program is to dramatically improve U.S. Navy submarine superiority. HyDem will apply breakthroughs in materials, material system technologies, developed	-	-	16.500

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
under the Hybrid Multi Material Rotor (HMMR) program budgeted in PE 0602715E, Project MBT-01, and multi-disciplinary design methods to a Virginia Class Submarine propulsor, a critical component in submarine performance. The U.S. Navy's ability to operate their submarine fleet with improved capability allows for the creation of strategic surprise. Submarines could exploit expanded areas which were previously unattainable for the purpose of submarine warfare, including within missions of antisubmarine warfare (ASW), antisurface warfare (ASuW), intelligence, surveillance and reconnaissance (ISR) gathering, strike, Special Forces operations, and strategic deterrence. The HyDem program will design, manufacture, and supply the Navy with a novel component for integration into a new construction Virginia Class Submarine. The Navy will evaluate this component in sea trials. It is envisioned that the Navy will integrate this design change into the future development of the Virginia Class and Ohio Replacement Submarines, and back-fit previously constructed Virginia Class Submarines. This program will transition to the Navy. ***FY 2015 Plans:*** - Complete manufacturing drawings and tooling. - Complete structural building block testing. - Complete manufacturing of the first component to be installed on a Virginia Class submarine.			
Title: Undersea Architecture: Adaptive Infrastructure ***Description:*** All undersea systems eventually require a resupply of energy, offload of data, updates to system information, and maintenance and repair, depending upon their operational use profiles, usage and collection rates. These factors inhibit their use in collaborative networks and prevent the full exploitation of the potential of undersea systems. Building upon challenges identified under the Distributed Agile Submarine Hunting (DASH) program within Project NET-02, the Undersea Architecture program will overcome these limitations by developing the technologies necessary for autonomous, reliable, and secure undersea energy and data transfers to manned and unmanned fixed and mobile undersea systems; true plug, play, and operate standards; and rapid, cost effective deployment and sustainment technologies. The Undersea Architecture program will focus on orders of magnitude reductions in the cost and complexity of sustained undersea operations compared to conventional undersea systems, and will explore the trade-offs between manned, unmanned, and fixed infrastructure systems. The program will emphasize at-sea integrated demonstrations of increasing complexity. Undersea Architecture technologies will transition to the Navy. ***FY 2015 Plans:*** - Commence prototype energy and data distribution module system design and fabrication. - Commence autonomous undersea data transfer system experiments. - Assess system deployment sustainment options; develop cost model.	-	-	12.100

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Conduct component-level and initial system-level performance testing.			
Title: Blue Wolf ***Description:*** Undersea platforms have inherent operational and tactical advantages such as stealth and surprise. Platform drag due to fluid viscosity and platform powering requirements varies with the speed through the water. Platform energy and power density limitations create two distinct operational usage profiles: one for unmanned undersea vehicles (low speed, long endurance) and another for undersea weapons (high speed, short endurance). Designers have historically solved this with hybrid systems such as the Navy's Vertical Launch Anti-Submarine Rocket, or by increasing the size of undersea systems. However, hybrid systems can be vulnerable to air and undersea defensive systems and larger undersea systems can result in significant launch platform modifications. The Blue Wolf program seeks to provide a radically different solution by leveraging the powering and performance results from the previously funded Super-Fast Submerged Transport program, PE 0602702E, Project TT-03, to develop and demonstrate an undersea vehicle with endurance and speed capabilities beyond conventional undersea systems within the weight and volume envelopes of current Navy undersea systems. Significant technical challenges to be addressed include: reliable undersea connectivity, autonomy, guidance, and navigation; obstacle avoidance; and propulsion and energy systems compatible with existing manned platform safety requirements. The program will culminate in a series of at-sea demonstrations and will transition to the Navy. ***FY 2015 Plans:*** - Commence platform design and technology assessments and system safety and effectiveness modeling. - Establish baseline test platform architecture and conduct check-out testing.	-	-	13.910
Title: Unmanned/Minimally-manned Underwater Vehicle (UMUV) ***Description:*** The Unmanned/Minimally-manned Underwater Vehicle (UMUV) program sought to develop a vehicle specifically designed to operate in the littoral battlespace with the capability of performing littoral missions that span a wide range of complexity and could be performed with a small manned crew or autonomously (i.e., unmanned) depending upon mission requirements. The UMUV sought to have the autonomy, range and endurance to drive to the fight from a safe basing location, and be capable of carrying the full range of payloads that are needed to support operational needs in littoral waters, and will provide the capability to perform missions where risk to personnel limits our willingness to execute these missions. The program explored low-cost derivatives of commercial underwater vehicles, the integration of advanced communication and sensor technologies, and the teaming of the UMUV with manned systems. Technologies from the UMUV program will be made available to the Navy.	2.000	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Explored and evaluated the conceptual design of alternative approaches to the UMUV system.			
Accomplishments/Planned Programs Subtotals	41.464	50.853	80.882

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 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-06 / *NETWORK-CENTRIC 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
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	110.416	171.408	242.900	-	242.900	207.800	144.000	43.000	-	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Classified DARPA Program	110.416	171.408	242.900
Description: This project funds Classified DARPA Programs. Details of this submission are classified.			
FY 2013 Accomplishments: Details will be provided under separate cover.			
FY 2014 Plans: Details will be provided under separate cover.			
FY 2015 Plans: Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	110.416	171.408	242.900

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR 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	-	272.095	276.364	312.821	-	312.821	279.927	280.978	300.409	309.318	-	-
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	-	52.368	53.329	55.743	-	55.743	55.412	55.904	72.557	80.404	-	-
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	-	102.497	105.288	104.811	-	104.811	91.323	109.194	137.188	147.920	-	-
SEN-03: *EXPLOITATION SYSTEMS*	-	47.557	40.197	64.071	-	64.071	63.246	70.880	74.664	80.994	-	-
SEN-06: *SENSOR TECHNOLOGY*	-	69.673	77.550	88.196	-	88.196	69.946	45.000	16.000	-	-	-

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

A. Mission Description and Budget Item Justification

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

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

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

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	299.438	286.364	276.749	-	276.749
Current President's Budget	272.095	276.364	312.821	-	312.821
Total Adjustments	-27.343	-10.000	36.072	-	36.072
• Congressional General Reductions	-0.389	-			
• Congressional Directed Reductions	-27.449	-10.000			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	8.146	-			
• SBIR/STTR Transfer	-7.651	-			
• TotalOtherAdjustments	-	-	36.072	-	36.072

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 reduction to eliminate program growth.

FY 2015: Increase reflects new efforts in Software-Defined Intelligence, Surveillance, and Reconnaissance (ISR), Battlefield Evidence and an increase in classified programs.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency			Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-01 / *SURVEILLANCE AND COUNTERMEASURES 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
SEN-01: *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*	-	52.368	53.329	55.743	-	55.743	55.412	55.904	72.557	80.404	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Adaptable Navigation Systems (ANS)	14.802	15.991	15.982

Description: The Adaptable Navigation Systems (ANS) program will provide the U.S. warfighter with the ability to effectively navigate all environments including when Global Positioning System (GPS) is unavailable due to hostile action (jamming) or blockage by structures, foliage, or other environmental obstacles. The ANS approach relies on three major technology innovations. The first is development of a new type of inertial measurement unit (IMU) that requires fewer GPS position fixes. Using cold atom technology, this IMU exceeds the performance of strategic-grade IMUs, with comparable size, weight, and power (SWaP). The second innovation uses Signals of Opportunity (SoOp) from a variety of ground-, air-, and space-based sources, as well as natural SoOps to reduce dependency on GPS position fixes. These will be received on the Services' forthcoming software-defined radios and will use specially tailored algorithms to determine position. The third technology innovation allows SoOp-based position information to be combined with inertial and other sensors to enable flexible navigation systems that can be reconfigured in the field to support any platform or environment. This capability will enhance new advanced component technology for positioning, navigation, and timing (PNT) emerging from other programs in the form of Micro Electro-Mechanical System devices, clocks, and new aiding sensors. Recent advances in mathematics, data abstraction, and network architectures will build upon these capabilities by enabling "plug-and-play" integration of both existing and future navigation components and processing to allow real-time reconfiguration of navigation systems. If successful, major improvements in navigation accuracy and system cost could also be realized. Early transition partners would include all Services, with emphasis on platforms and users that must operate in multiple environments, such as Naval forces.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-01 / *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Developed and tested candidate filter, sensor, and architecture design for plug-and-play system. - Commenced developing ANS reference stations to user-selected, platform-specific form factors. - Demonstrated integration of SoOp-based ranging and navigation into ANS systems. - Tested and evaluated ANS systems for sea-, air-, and land-based platforms in GPS-denied mission scenarios. - Began designing second-generation 6-degree-of-freedom cold atom IMU. ***FY 2014 Plans:*** - Complete development of candidate filter, sensor, and architecture design for plug-and-play system. - Test and evaluate first-generation 6-degree-of-freedom cold atom-based IMU. - Demonstrate flexible, real-time operation of ANS systems on sea-, air-, and land-based platforms using relevant sensor suites. - Transition novel navigation measurement technologies, via new sensors, algorithms, or measurement enhancements, into ANS demonstration systems. - Evaluate options for size, weight, power, and cost (SWaP-C)-constrained reference stations that enable full SoOp-based navigation. - Complete second-generation 6-degree-of-freedom cold atom IMU and design cold atom-based clock that has the same form/fit/function of existing Cesium-based clocks. - Evaluate candidate approaches for a wireless time transfer and positioning system that provides GPS-level performance globally with minimal infrastructure, and a compact, jam-proof PNT sensor that provides better than GPS-level performance. ***FY 2015 Plans:*** - Demonstrate inertial navigation performance of a second-generation cold atom-based IMU on a submarine platform. - Demonstrate the navigation performance, independent of GPS, of the integrated ANS system, comprised of various sensors, including IMUs and SoOp receivers, and a sensor fusion processor, on multiple sea-, air-, and land-based platforms.			
Title: Adaptable, Low Cost Sensors ***Description:*** The objective of the Adaptable, Low Cost Sensors program is to leverage commercial technology and manufacturing techniques to improve the development time and significantly reduce the cost of sensors and sensor systems. Currently, military sensors are designed and developed with unique, mission-specific hardware and software capability requirements into a single, fully integrated device. This approach significantly increases both the cost and difficulty of meeting continuously changing requirements and upgrades. Commercial processes, such as those used in the smart phone industry, create reference designs for common system functions and features to accelerate system development time. This makes change to requirements and completing upgrades far simpler. Adopting these commercial processes enables a mission-independent, designed-to-cost "commercial smart core" that can be combined with an appliqué of mission-specific hardware to provide low cost, independently upgradable, and previously infeasible sensor system distribution capabilities. The Smart Munitions effort plans to use ADAPT's	19.116	11.338	6.904

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-01 / *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
sensing, processing, communications, and location capabilities to provide positive identification and man-in-the-loop control of distributed, unattended ground sensor systems. It also seeks to develop a reference design to demonstrate capability and develop tactics for unattended sensors. This program will transition to the Services. ***FY 2013 Accomplishments:*** - Manufactured second version of commercial smart core. - Developed mobile and airborne development kits using the core hardware and software technology. - Refined smart core re-usable software and ground mission software communications, networking, distributed processing, location, and orientation. - Developed and demonstrated Smart Munitions reference design using a ground sensor packaging of the core technology. - Developed image, video detection, tracking, and display utilities to provide positive target identification in support of the Smart Munitions effort. ***FY 2014 Plans:*** - Develop additional reference designs, including Quad-rotor UAV, Fixed Wing UAV, Unmanned Undersea Vessel (UUV), and Software-Defined Radio. - Configure hardware for heterogeneous distributed sensor mission. - Field test Smart Munitions with multiple sensor modalities. ***FY 2015 Plans:*** - Field test and demonstrate mobile coordinated device operation using ADAPT reference designs (Smart Munitions and UAVs).			
Title: Multi-Function Optical Sensing ***Description:*** The proliferation of radio frequency (RF)-based countermeasures, such as digital radio frequency memory (DRFM), has presented challenges to the effectiveness of data sensors. The Multi-Function Optical Sensing (MOS) program will enable an alternative approach to detecting, tracking, and performing non-cooperative target identification, as well as providing fire control for fighter class and long-range strike aircraft. This program leverages emerging high-sensitivity focal plane array (FPA) and compact, multiband laser systems technology in the near/mid/long-wave infrared bands to enable the development of a multi-function optical system. Technical challenges include the demonstration of inexpensive, multiband, large-format, photon-counting, high-bandwidth receivers and their integration into a multi-optical sensor suite compatible with airborne assets. The Multi-Function Optical Sensor program seeks to advance the state of the art of components and technology to support an all-optical airborne system that can detect, geolocate, and identify targets at standoff ranges. Technologies from this program will transition to the Services. ***FY 2013 Accomplishments:***	18.450	26.000	22.857

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-01 / *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated development of multiband, high-speed active focal plane arrays. - Initiated development of variable-waveform, high power lasers that demonstrate high wall plug efficiency. - Developed preliminary system architectures for airborne multi-function optical sensors. - Simulated sensor measurements of targets at relevant ranges including the effects of turbulence and atmospheric scattering. - Initiated development of new algorithms and signal processing approaches for effective use of multi-function optical sensing measurements for target tracking and identification. - Investigated concept of operations (CONOPS) for the deployment of a multi-function optical sensor. - Conducted reduced range target measurements to validate simulations. ***FY 2014 Plans:*** - Complete design of prototype sensor through critical design review. - Initiate development of a first-generation prototype sensor. - Incorporate results of CONOPS and algorithm performance on simulated data to refine objective system performance requirements. - Initiate investigation of communications protocols for the multi-optical sensor to interact with other systems and platforms. - Continue development of sensor data-processing algorithms to improve target tracking and identification. - Initiate advanced system signal-processing methodologies for real-time performance and integration into the second-generation sensor system. - Investigate alternative approaches for an active cueing system. ***FY 2015 Plans:*** - Complete the development of the prototype system. - Perform demonstrations with the prototype system in the appropriate environment. - Incorporate advanced data-processing and target tracking algorithms into the sensor processing chain. - Initiate the development of a second-generation prototype sensor, which will demonstrate the full capability out to operational ranges. - Initiate packaging activity for the incorporation of the developed active focal plane arrays and variable-waveform lasers into the second-generation architecture. - Develop a hardware traceability strategy for the second-generation prototype sensor, which will be part of a roadmap for the development of a fully operational system.			
Title: Software-Defined ISR ***Description:*** Currently, radars, electronic warfare (EW) systems, and Electronic Support Measures (ESM) systems consist of custom software and hardware. Developing new modes for these systems is costly and time consuming, and porting modes among intelligence, surveillance, and reconnaissance (ISR) platforms is nearly impossible. The Software-Defined ISR program	-	-	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-01 / *SURVEILLANCE AND COUNTERMEASURES TECHNOLOGY*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
seeks to improve the utility of existing and emerging sensor and EW systems by enabling rapid development and porting of modes among open-architecture systems and permitting users to efficiently deploy new capabilities to current radar, EW, and ESM systems via software upgrades. This will allow the Services to leverage investments in mode development by re-using software across different platforms and when platforms are upgraded, while enhancing operational capability by allowing a system to be optimized to the mission. This program will develop and demonstrate software tools to enable rapid development and porting of ISR modes on open-architecture hardware systems. Radar, EW, and ESM modes will be developed and demonstrated to pave the way for future development of cognitive radar capabilities, and ported among Open Architecture (OA) compliant ISR systems to build and demonstrate a mode development environment (ModeLab). The key elements of the Software-Defined ISR program are as follows: to develop Hardware Abstraction Layer (HAL) tools to support rapid porting of modes onto open-architecture systems, including the Flexible Open-Architecture Middleware (FOAM) and the ModeLab for rapid mode development; to demonstrate the ability to rapidly develop and port new radar, EW, and ESM modes to open-architecture RF systems; to develop and demonstrate implementation of multiple modes spanning a range of performance and capabilities; and to perform data collections to support mode development. This program will transition to the Services. ***FY 2015 Plans:*** - Assemble requirements for FOAM to provide an abstraction of the underlying software and hardware architectures and provide an efficient interface from the mode layer to the radar. - Commence FOAM design. - Assemble requirements for a mode development environment (ModeLab) that can support radar, EW, and ESM functions. - Commence design of ModeLab.			
Accomplishments/Planned Programs Subtotals	52.368	53.329	55.743

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 / 3	R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*	Project (Number/Name) SEN-02 / *SENSORS AND PROCESSING 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
SEN-02: *SENSORS AND PROCESSING SYSTEMS*	-	102.497	105.288	104.811	-	104.811	91.323	109.194	137.188	147.920	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Behavioral Learning for Adaptive Electronic Warfare (BLADE)	16.000	17.100	5.000

Description: The Behavioral Learning for Adaptive Electronic Warfare (BLADE) program will develop the capability to jam adaptive and rapidly evolving radio frequency (RF) threats in tactical environments and at tactically-relevant timescales. This will change the paradigm for responding to evolving threats from lab-based manual development to an adaptive in-the-field systems approach. When an unknown or advanced RF threat appears, BLADE networked nodes will dynamically characterize the emitter, synthesize an effective countering technique, and evaluate jamming effectiveness by iteratively probing, learning, and adapting to the threat. An optimization process will tailor real-time responses to specific threats, producing a countermeasure waveform that maximizes jam effectiveness while minimizing the required jamming resources. Thus BLADE will enable the rapid defeat of new RF threats and provide the warfighter with real-time feedback on jam effectiveness. The program is planned for transition to the Services.

FY 2013 Accomplishments:
- Optimized algorithms for real-time operations and ported to breadboard computing platforms.
- Performed construction, integration, and testing of real-time hardware implementation.
- Developed threat libraries and testing methodology.

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Created transition plan in concert with relevant programs of record and Service partners. ***FY 2014 Plans:*** - Perform test and evaluation of real-time prototypes in a laboratory environment based on Government provided threats. - Extend and enhance algorithms for over-the-air mobile operations in cluttered RF environments. - Demonstrate accurate real-time electronic warfare (EW) battle damage assessment for transition partner defined threats. ***FY 2015 Plans:*** - Formally test and evaluate prototype systems in an operationally relevant environment. - Quantify the minimum hardware requirements, including processing and memory, necessary to execute the BLADE algorithms on transition platforms.			
Title: Adaptive Radar Countermeasures (ARC)	8.041	18.221	26.975
Description: The goal of the Adaptive Radar Countermeasures (ARC) program is to provide effective electronic countermeasure (ECM) techniques against new or unknown threat radars. Current airborne electronic warfare (EW) systems rely on the ability to uniquely identify a threat radar system to apply an appropriate preprogrammed countermeasure technique which can take many months to develop. Countering radar systems is increasingly challenging as digitally programmed radars exhibit novel behaviors and agile waveform characteristics. ARC will develop new processing techniques and algorithms that adapt in real-time to generate suitable countermeasures. Using techniques such as state modeling, machine learning, and system probing, ARC will learn the behavior of the threat system, then choose and implement an appropriate countermeasure strategy. The program is planned for transition to the Services. ***FY 2013 Accomplishments:*** - Developed algorithmic approaches to isolate novel radar signals in the presence of other hostile, friendly, and neutral signals, and to deduce the threat posed by that signal. - Designed high-level system architecture and developed preliminary software application programming interfaces and interface control documents. - Developed preliminary techniques for synthesizing a countermeasure that achieves a desired effect on the threat radar. ***FY 2014 Plans:*** - Complete detailed system architecture design and validate software interfaces. - Conduct offline testing to demonstrate signal analysis and characterization of unanticipated or ambiguous radar signals. - Assess countermeasure effectiveness from over-the-air observable changes in the threat radar signals. - Develop methodologies for closed-loop system testing against adaptive radar threats.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Obtain baseline hardware from transition partners for integration and testing of algorithms in a laboratory environment. ***FY 2015 Plans:*** - Refine and integrate component algorithms for end-to-end system testing in a hardware-in-the-loop laboratory environment. - Begin porting software algorithms onto transition partner provided baseline EW systems to demonstrate enhanced performance against unknown or ambiguous threat radars. - Develop detailed flight test plans in concert with relevant programs of record and Service partners.			
Title: Military Imaging and Surveillance Technology (MIST)	36.455	30.863	22.471
Description: The Military Imaging and Surveillance Technology (MIST) program is developing a fundamentally new optical Intelligence, Surveillance, and Reconnaissance (ISR) capability that can provide high-resolution 3-D images to locate and identify a target at much longer ranges than is possible with existing optical systems. Several prototype optical surveillance and observation systems are being developed that: (1) demonstrate probabilities of recognition and identification at distances sufficient to allow stand-off engagement; (2) overcome atmospheric turbulence, which now limits the ability of high-resolution optics; and (3) increase target identification confidence to reduce fratricide and/or collateral damage. The program will develop and integrate the necessary component technologies including high-energy pulsed lasers, receiver telescopes that have a field of view and depth of field that obviates the need for steering or focusing the optical system, computational imaging algorithms to improve system resolution, and data exploitation and analysis tools. Advances in laser systems, digital imagers, and novel image processing algorithms will be leveraged to reduce the overall size, weight, and power (SWaP) of imaging systems to allow for soldier portable and UAV platform integration. MIST will also continue to integrate technologies developed under the Crosswind Sensor System for Snipers (C-WINS) and the Dynamic Image Gunsight Optics (DInGO) efforts. MIST will develop an optical rifle scope that enables a soldier, with minimal training, to shoot a firearm with marksman accuracy at range while also enhancing the capability for close quarters combat. The MIST program will transition the optical ISR technology to the Air Force and SOCOM. ***FY 2013 Accomplishments:*** - Completed development of MIST short-range 3-D imaging brassboards. - Completed Preliminary Design Review of the MIST long-range 3-D imaging system for operation on aerial platforms. - Initiated brassboard development and critical design review-level design of long-range MIST 3-D imaging technology. - Demonstrated key technologies to enable operation of MIST 3-D imaging technologies at increased ranges. - Demonstrated a fiber laser system compatible with the MIST long-range platforms. - Completed and transitioned the digital rifle-scope prototypes. ***FY 2014 Plans:*** - Complete and transition the short-range 3-D imaging prototypes and technology to the Services.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete brassboard and ground demonstrations of the long-range 3-D imaging systems, including testing and demonstration of critical subsystem components. - Complete packaging of the high-power pulsed laser required for the MIST long-range prototypes. - Commence long-range 3-D imaging prototype design and development. - Develop most promising crosswind sensor technologies. - Develop, test, and transition near-hypervelocity rounds for snipers. - Investigate alternate uses of crosswind sensor technology. ***FY 2015 Plans:*** - Complete prototypes and airborne demonstrations of the long-range 3-D imaging systems, including testing and demonstration. - Transition the long-range MIST systems to the Air Force. - Transition the short-range 3-D imaging prototypes and technology to the Services. - Complete packaging and testing of the flight qualified MIST laser. - Complete prototypes of the long-range 3-D imaging systems. - Conduct airborne testing and demonstrations of the long-range 3-D imaging systems.			
Title: Multifunction RF ***Description:*** The Multifunction RF (MFRF) program goal is to enable U.S. rotary wing aircraft forces to fight effectively in all forms of severely Degraded Visual Environments (DVE) when our adversaries cannot. The program goes beyond landing aids in DVE to address all elements of combat to include landing, takeoff, hover/taxi, enroute, navigation, lethality, and survivability. Building on previous RF sensors advancements, the program will seek to eliminate many redundant RF elements of current independently-developed situational and combat support systems to provide multifunction capability with flexibility of adding new mission functions. This will reduce the overall size, weight, power, and cost (SWaP-C) of subsystems and protrusive exterior antennas on military aircraft, enabling greater mission capability with reduced vehicle system integration burden. The program approach includes; 1) Development of synthetic vision for pilots that fuses sensor data with high-resolution terrain databases, 2) Development of Advanced Rotary Multifunction Sensor (ARMS), utilizing silicon-based tile arrays, for agile electronically scanning technology at low SWAP-C, 3) Implementation of software development kit to re-define modes as required by mission or platform needs; ease of adding new modes via software without hardware modifications. Transition is planned to the Services. ***FY 2013 Accomplishments:*** - Began laboratory testing of ARMS components suitable for flight testing. - Completed development and laboratory testing of key subsystem technologies for RF waveforms and arrays. - Flight tested synthetic vision avionics backbone with sensor on selected aircraft platform.	27.280	20.354	14.375

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Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Investigated advanced silicon tile designs and array backplanes to improve system size, weight, and power (SWaP). ***FY 2014 Plans:*** - Finalize tile array and array backplane technology selection for sub-array builds. - Begin fabrications of sub-arrays for ARMS laboratory demo. - Demonstrate integration of silicon-based tile sub-array and digital receiver/exciter backplane. - Demonstrate radar software development kit suitable for redefining system functions of integrated system. ***FY 2015 Plans:*** - Demonstrate utility of software development kit through third party programming. - Complete laboratory testing of ARMS for flight testing. - Conduct laboratory demo with integrated ARMS, synthetic vision backbone, and multifunction software development kit.			
Title: Video-rate Synthetic Aperture Radar (ViSAR) ***Description:*** Recent conflicts have demonstrated the need for close air support by precision attack platforms such as the AC-130J or the MH-60 class helicopters in support of ground forces. Under clear conditions, targets are easily-identified and engaged quite effectively, but in degraded environments the atmosphere can inhibit traditional optical sensors. The AC-130J must fly above cloud decks in order to avoid anti-aircraft fire, negating optical targeting sensors. Similarly, rotary/wing blades in urban operations generate copious amounts of dust that prevent circling assets from supplying cover fire for ground forces. The Video-rate Synthetic Aperture Radar (ViSAR) program seeks to develop a real-time spotlight synthetic aperture radar (SAR) imaging sensor that will provide imagery of a region to allow high-resolution fire direction in conditions where optical sensors do not function. Technology from this program is planned to transition to AFSOC. ***FY 2013 Accomplishments:*** - Initiated hardware design and development of transmitter and receiver components. - Evaluated RF sensor design concepts that will enable high-resolution targeting information through low altitude clouds. - Assessed impacts of various platforms and global weather conditions on targeting performance. ***FY 2014 Plans:*** - Complete development of transmitter and receiver components for sensor demonstration. - Initiate hardware design and development of ViSAR system. - Demonstrate performance of laboratory quality objective transmitter amplifier. - Complete phenomenology models to support system simulations. ***FY 2015 Plans:*** - Complete development of flight-worthy high power amplifier.	12.221	18.750	16.990

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Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Demonstrate the integration of low power transmitter and receiver components into sensor. - Integrate phenomenology data into scene simulator and generate data for demonstration of algorithm performance.			
Title: Precision Timing Enabling Cooperative Effects ***Description:*** Building on technologies developed in the Adaptable Navigation Systems program, budgeted in Project SEN-01, the Precision Timing Enabling Cooperative Effects program will enable precision cooperative effects by developing global time transfer and synchronization systems independent of GPS. As a corollary to time synchronization, this program will also enable GPS independent positioning to maintain precise time synchronization between collaborating mobile users. Key attributes of this program are global availability; minimal and low cost infrastructure; anti-jamming capability; and performance equal to or better than GPS through recent advances in cold atom-based clocks and optical time transfer. Other recent advances show that navigation systems using non-traditional sensors can be rapidly configured to provide accurate positioning, navigation, and timing (PNT) capabilities. This program will build on these and other PNT technologies, and extend this level of performance to include the underwater environment in addition to surface, indoor, and airborne environments. Demonstrations on relevant platforms in relevant environments will be used to validate the technology. This program will transition to the Services, emphasizing platforms that operate in GPS-denied environments. ***FY 2015 Plans:*** - Begin developing a precision time transfer and synchronization system using cold atom-based clocks. - Begin developing a wireless precision time transfer system that provides GPS-level performance globally with minimal infrastructure. - Begin developing compact, jam-proof PNT sensors that provide better than GPS-level performance. - Demonstrate GPS-independent PNT using non-PNT sensors that are already installed on the platform (e.g., radars, imagers, communications, etc.). - Begin developing a PNT system that is capable of providing GPS-level positioning and timing performance to undersea users from large standoff distances, and plan for demonstrations.	-	-	9.000
Title: Automatic Target Recognition (ATR) Technology ***Description:*** Automatic target recognition (ATR) systems provide the capability to detect, identify, and track high value targets from collected sensor data. Current ATRs are typically designed for specific sensors and static due to pre-programmed target lists and operating mode, limiting mission execution capabilities. Extending ATR technology to accommodate sensor upgrades or include new emerging targets can be costly and time consuming. The objective of the ATR Technology program is to develop technologies that reduce operation limitations while also providing significant performance improvements, dramatically reduced development times, and reduced life cycle maintenance costs. Recent breakthroughs in deep learning, sparse representations, manifold learning, and embedded systems offer promise for dramatic improvements in ATR. Three core areas the program	-	-	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
will focus on are: development of on-line adaptive algorithms that enable performance-driven sensing and ATR; recognition technology that enables rapid incorporation of new targets; and technologies that dramatically reduce required data rates, processing times, and the overall hardware and software footprint of ATR systems. ATR technology developed under the program is planned for transition to the Services. ***FY 2015 Plans:*** - Develop modeling and simulation framework for testing and evaluating performance-driven ATR systems. - Establish baseline performance for existing ATR algorithms against challenge problem data sets. - Design and execute a data collection experiment to provide additional data for testing. - Initiate development of advanced algorithms that support signature generalization and reduced signature database complexity.			
Title: Advanced Airborne Optical Sensing ***Description:*** The Advanced Airborne Optical Sensing program developed electro-optical and infrared sensors and processing technologies for aerial platforms. Significant challenges arose as the result of two warfighting trends. First, the ever-changing mix of airborne platforms now includes a greater number of smaller UAVs. Second, the target set is increasingly challenging and now includes vehicles and individual dismounts that operate under foliage and in urban canyons, using camouflage, obscurants, and other means of concealment. In response to these challenges, the Advanced Airborne Optical Sensing program developed enhanced optical, electro-optical, photonic and other technologies for airborne optical sensing systems. The remaining effort in this program, HALOE (High Altitude Lidar Operations Experiment), demonstrated, in an operational environment, the full capability of a 3-D imaging system. HALOE successfully completed the CONUS flight testing phase and was deployed OCONUS for further testing and system checkout to address current and emerging needs of U.S. forces under the direction of commanders in theater during 2011. The completed HALOE system transitioned to the U.S. Army. ***FY 2013 Accomplishments:*** High Altitude Lidar Operations Experiment (HALOE) - Developed additional applications for the high performance LIDAR components embedded within the HALOE system to optimize size, weight, and power (SWaP) for alternate platforms. - HALOE system successfully transitioned to U.S. Army Geospatial Center.	2.500	-	-
Accomplishments/Planned Programs Subtotals	102.497	105.288	104.811

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 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-02 / *SENSORS AND PROCESSING SYSTEMS*

D. Acquisition Strategy

N/A

E. Performance Metrics

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

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency												Date: March 2014
Appropriation/Budget Activity 0400 / 3					R-1 Program Element (Number/Name) PE 0603767E / *SENSOR TECHNOLOGY*				Project (Number/Name) SEN-03 / *EXPLOITATION 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
SEN-03: *EXPLOITATION SYSTEMS*	-	47.557	40.197	64.071	-	64.071	63.246	70.880	74.664	80.994	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Insight	36.842	36.000	48.539
Description: Insight is developing the next generation multi-intelligence (multi-INT) exploitation and resource management system. Insight provides new exploitation capabilities through an integrated, standards-based system that is designed for mission flexibility and cross-theater applicability. Insight will enable detection of threat networks through combination and analysis of information from imaging and non-imaging sensors and other sources. The technical approach emphasizes model-based correlation, adversary behavior modeling, threat network analysis tools, resource management tools, a unified data management and processing environment, novel exploitation algorithms and analysis methodologies, and tools to integrate human and machine processing, including visualization, hypothesis manipulation, on-line learning, and distributed social intelligence. Insight development activities leverage both virtual and physical test bed environments. The virtual test bed enables evaluation of alternative sensor mixes and algorithms under extended operating conditions. The physical test bed enables live testing under realistic operational conditions using current and next generation sensing and processing systems. Insight technology development is being coordinated with the following potential transition sponsors: Army Program Executive Office-Intelligence, Electronic Warfare & Sensors, Distributed Common Ground System (DCGS) - Army, Army Intelligence and Security Command, Air Force - Distributed Common Ground Station, and the National Geospatial-Intelligence Agency. Insight provides a unified architecture for plug-and-play ISR with extensibility to all Services and Combatant Commands, initially CENTCOM, SOCOM, and PACOM.			
FY 2013 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-03 / *EXPLOITATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Performed comprehensive field tests with Army and Marine Corps user and stakeholder communities to validate system operational utility highlighting collection, resource management, and exploitation of data from physical sensors, human sources, and contextual databases. - Demonstrated capabilities including multi-source correlation of vast scale across all information sources; dynamic sensor tasking, cross-cueing and handoff; hypothesis management of uncertain data; and inference management to prioritize and explain abnormal behaviors. - Integrated the Insight system with live pre-deployment training exercises in coordination with DCGS-Army. - Conducted virtual test bed exercises to demonstrate exploitation, resource management, visualization, and simulation capabilities. - Drafted an agreement to transition Insight technology to DCGS-Army. - Provided system integration and field test support for a full field of view real-time wide-area motion imagery (WAMI) tracker which has since deployed to theater via Air Force. ***FY 2014 Plans:*** - Finalize formal transition agreements and transfer technology to DCGS-Army and Air Force DCGS. - Adapt demonstrated capabilities to emerging operational environments including integration of relevant information sources and sensor models. - Augment the reasoning component of the system in support of the mission profiles of emerging operational environments. - Test and mature advanced fusion technologies in live and virtual operational environments. - Tailor component and system level capabilities to specific transition partner objectives. ***FY 2015 Plans:*** - Adapt capabilities to emerging operational environments, to include integration of additional, non-traditional sensors and information sources. - Test and mature advanced analytic and resource management technologies in live and virtual operational environments. - Execute additional live field tests in coordination with military training rotations to demonstrate improvements and maturity of system capabilities in dynamic operational environments. - Deliver integrated capabilities that address key performance parameters of transition partner programs of record aligned with their software release cycles.			
Title: Worldwide Intelligence Surveillance and Reconnaissance (WISR) ***Description:*** The Worldwide Intelligence Surveillance and Reconnaissance (WISR) system will provide ISR capability in denied areas. The U.S. military has limited capability to obtain airborne ISR observations of many critical problem areas, and overhead observations are limited by sensor resolution, collection timeline, and platform geometry. However, millions of videos posted worldwide reflect events and areas of interest for national security, and the number is rapidly increasing. WISR will use ground-level video and still images to produce 3-D and 4-D reconstructions of events and use these reconstructions to code descriptions	7.215	4.197	5.532

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-03 / *EXPLOITATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
of dynamic content, rather than focusing on the identification and movement of individual objects and humans in the scene. WISR constructs will be suitable for describing and differentiating patterns-of-life to reflect local and societal changes. The program will use this data in support of three missions: intelligence preparation for expeditionary forces entering a new area of operation, reconstruction of significant events worldwide, and battle damage assessment. These techniques will transition to operational commands and the intelligence community. ***FY 2013 Accomplishments:*** - Created a collection of open source video clips and identified/quantified differences from military ISR video in terms of metadata, perspective, field of view, and persistence. - Explored the hypothesis that analysis of a video collection at a macroscopic level to characterize crowd behavior is feasible even when tracking all targets is not practical. - Developed a mathematical approach for extremely efficient computation of crowd properties based on density functional theory and demonstrated/evaluated the approach via simulation. ***FY 2014 Plans:*** - Create techniques for automatically correlating and integrating diverse media types such as still images, videos, audio, and text. - Develop coding methodologies to describe scenes in terms of their macroscopic, non-culturally dependent characteristics. ***FY 2015 Plans:*** - Develop a culturally dependent query engine that allows intelligence analysts to find scenes of relevance to a particular mission analysis.			
Title: Battlefield Evidence ***Description:*** The Battlefield Evidence program will create technologies for searching and fusing diverse types of content and media to derive evidence of adversary activities. Current approaches to forensics are manpower intensive and require analysts and investigators to undertake painstaking searches of available information and then to manually fuse this information into logical event timelines. Battlefield Evidence will develop, integrate, and extend text, speech, and video search technologies to provide the relevant spatio-temporal information. The program will also develop and apply techniques to fuse this information for immersive display to enable human analysts to efficiently and intuitively look for suspicious activities, non-obvious relationships, and other patterns for follow-up. Battlefield Evidence technologies will transition to operational commands, the intelligence community, and law enforcement agencies. ***FY 2015 Plans:*** - Develop operator-in-the-loop technologies for fusing new types of content and media including open source and intercepted multi-lingual speech and text and other spatio-temporal information.	-	-	10.000

Exhibit R-2A, RDT&E Project Justification: PB 2015 Defense Advanced Research Projects Agency		Date: March 2014
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-03 / *EXPLOITATION SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Design a structured representation language that fuses data from the multiple input sources and highlights inconsistencies for analyst attention. - Initiate development of an immersive capability to walk through and interact with reconstructed environments and events. - Create techniques for representing the level of certainty or confidence in a combined representation.			
Title: Wide Area Network Detection (WAND) ***Description:*** The Wide Area Network Detection (WAND) program developed methods to detect, characterize, and identify threat networks from imaging and other sensors, including national, theater, and organic sensors. Critical performance metrics are timeliness, accuracy, error rates, and interpretation workload. The program addressed the challenges of network/target identification, acquisition, tracking, and denial in difficult environments. WAND technologies applied advanced signal processing, sensor fusion, and platform control to leverage advances in sensor capabilities. Technologies developed under the WAND program have transitioned to SOCOM. ***FY 2013 Accomplishments:*** - Demonstrated integrated detection of sites, movements, and communications associated with threat network activity. - Demonstrated ability to create accurate wide-area motion imagery (WAMI) tracklets by post processing full field of view airborne video data. - Demonstrated ability to stitch WAMI tracklets into complete origin-to-destination (trip) tracks. - Demonstrated ability to fuse radio frequency (RF) detection data with WAMI tracklet data to improve tracklet stitching accuracy. - Demonstrated integrated analyst-machine processing to improve production efficiency and exploitation accuracy. - Transitioned RF detection system processing algorithms and optimized array to SOCOM.	3.500	-	-
Accomplishments/Planned Programs Subtotals	47.557	40.197	64.071

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 / 3	**R-1 Program Element (Number/Name)** PE 0603767E / *SENSOR TECHNOLOGY*	**Project (Number/Name)** SEN-06 / *SENSOR 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
SEN-06: *SENSOR TECHNOLOGY*	-	69.673	77.550	88.196	-	88.196	69.946	45.000	16.000	-	-	-

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

A. Mission Description and Budget Item Justification

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

B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Classified DARPA Program	69.673	77.550	88.196
Description: This project funds Classified DARPA Programs. Details of this submission are classified.			
FY 2013 Accomplishments: Details will be provided under separate cover.			
FY 2014 Plans: Details will be provided under separate cover.			
FY 2015 Plans: Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	69.673	77.550	88.196

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605502E / *SMALL BUSINESS INNOVATION RESEARCH*

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	-	70.839	-	-	-	-	-	-	-	-	-	-
SB-01: *SMALL BUSINESS INNOVATION RESEARCH*	-	70.839	-	-	-	-	-	-	-	-	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

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

A. Mission Description and Budget Item Justification

In accordance with Public Law No: 112-81 (National Defense Authorization Act) and Small Business Technology Transfer Program Reauthorization Act, the DARPA Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to enable fundamental discoveries and technological breakthroughs that provide new military capabilities.

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	-	-	-	-	-
Current President's Budget	70.839	-	-	-	-
Total Adjustments	70.839	-	-	-	-
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	70.839	-			

Change Summary Explanation

FY 2013: Increase reflects SBIR/STTR transfer.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Small Business Innovation Research	70.839	-	-
Description: The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are designed to provide small, high-tech businesses and academic institutions the opportunity to propose radical, innovative, high-risk			

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 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605502E / *SMALL BUSINESS INNOVATION RESEARCH*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
approaches to address existing and emerging national security threats; thereby supporting DARPA's overall strategy to enable fundamental discoveries and technological breakthroughs that provide new military capabilities. ***FY 2013 Accomplishments:*** The DARPA SBIR and STTR programs were executed within OSD guidelines.			
Accomplishments/Planned Programs Subtotals	70.839	-	-

D. Other Program Funding Summary ($ in Millions)

N/A

Remarks

E. Acquisition Strategy

N/A

F. Performance Metrics

Not applicable.

Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Defense Advanced Research Projects Agency	Date: March 2014
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605898E / *MANAGEMENT HQ - R&D*

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	-	64.248	71.659	71.362	-	71.362	72.390	74.068	77.712	79.711	-	-
MH-01: *MANAGEMENT HQ - R&D*	-	64.248	71.659	71.362	-	71.362	72.390	74.068	77.712	79.711	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

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

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	69.767	71.659	73.182	-	73.182
Current President's Budget	64.248	71.659	71.362	-	71.362
Total Adjustments	-5.519	-	-1.820	-	-1.820
• Congressional General Reductions	-0.092	-			
• Congressional Directed Reductions	-5.427	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-	-			
• TotalOtherAdjustments	-	-	-1.820	-	-1.820

Change Summary Explanation

FY 2013: Decrease reflects Congressional reductions for Sections 3001 & 3004 and directed reductions, and sequestration adjustments.
FY 2015: Decrease reflects minor repricing.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Management Headquarters	64.248	71.659	71.362
Description: Management Headquarters			

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 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0605898E / *MANAGEMENT HQ - R&D*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
FY 2013 Accomplishments: - Fund civilian salaries and benefits, and administrative support costs. - Fund travel, rent and other infrastructure support costs. - Fund security costs to continue access controls, uniformed guards, and building security requirements. - Fund CFO Act compliance costs. ***FY 2014 Plans:*** - Fund civilian salaries and benefits, and administrative support costs. - Fund travel, rent and other infrastructure support costs. - Fund security costs to continue access controls, uniformed guards, and building security requirements. - Fund CFO Act compliance costs. ***FY 2015 Plans:*** - Fund civilian salaries and benefits, and administrative support costs. - Fund travel, rent and other infrastructure support costs. - Fund security costs to continue access controls, uniformed guards, and building security requirements. - Fund CFO Act compliance costs.			
Accomplishments/Planned Programs Subtotals	64.248	71.659	71.362

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 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0305103E / *CYBER SECURITY INITIATIVE*

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	-	1.961	-	-	-	-	-	-	-	-	-	-
CYB-01: *CYBER SECURITY INITIATIVE*	-	1.961	-	-	-	-	-	-	-	-	-	-
Quantity of RDT&E Articles	-	-	-	-	-	-	-	-	-	-		

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

A. Mission Description and Budget Item Justification

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

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	1.801	-	-	-	-
Current President's Budget	1.961	-	-	-	-
Total Adjustments	0.160	-	-	-	-
• Congressional General Reductions	-0.002	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.162	-			
• SBIR/STTR Transfer	-	-			

Change Summary Explanation

FY 2013: Increase reflects Congressional reductions for Sections 3001 & 3004 and reprogrammings.

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: Cyber Security Initiative	1.961	-	-
Description: The goal of the Cyber Security Initiative was to revolutionize the Nation's ability to conduct cyber operations by developing a persistent and cost-effective cyber testing environment. The National Cyber Range (NCR) program developed a network test bed that allows for research experimentation on diverse hardware and software topologies to produce qualitative and quantitative assessments of cyber security research and development programs through a safe, instrumented experimentation			

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 6: *RDT&E Management Support*	**R-1 Program Element (Number/Name)** PE 0305103E / *CYBER SECURITY INITIATIVE*

C. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
environment. The range is designed to replicate complex, heterogeneous networks. It has revolutionized cyber testing to enable efficient cyber experimentation and facilitate realistic testing of tools and techniques to enable high fidelity assessments of cyber tools and techniques and the rapid transition of research programs to operations. This program is available for leverage or use by all Federal Government organizations. The program has transitioned to the DoD's Test Resource Management Center (TRMC). ***FY 2013 Accomplishments:*** - Completed transition of the NCR to TRMC.			
Accomplishments/Planned Programs Subtotals	1.961	-	-

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.