

**UNCLASSIFIED**

**Department of Defense Fiscal Year (FY) 2008/2009 Budget Estimates  
February 2007**



**RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE  
Volume 1 - Defense Advanced Research Projects Agency**

**UNCLASSIFIED**

**Approved for Public Release  
Distribution Unlimited**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Table of Contents for Volume I

	<u>Page</u>
Table of Contents (by PE Number).....	i
Table of Contents (Alphabetical).....	ii
R-1 Exhibit for DARPA.....	iii

Table of Contents (by PE Number)

0601101E	Defense Research Sciences.....	1
0602303E	Information and Communications Technology .....	33
0602304E	Cognitive Computing Systems .....	59
0602383E	Biological Warfare Defense.....	87
0602702E	Tactical Technology .....	99
0602715E	Materials and Biological Technology .....	173
0602716E	Electronic Technology .....	197
0603286E	Advanced Aerospace Systems .....	239
0603287E	Space Programs and Technology.....	251
0603739E	Advanced Electronics Technology .....	273
0603760E	Command, Control, and Communications Systems .....	317
0603764E	Land Warfare Technology .....	351
0603766E	Network-Centric Warfare Technology .....	371
0603767E	Sensor Technology .....	397
0603768E	Guidance Technology .....	431
0605898E	Management Headquarters .....	439

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Table of Contents (Alphabetical)

Page

Table of Contents (Alphabetical)

0603286E	Advanced Aerospace Systems .....	239
0603739E	Advanced Electronics Technologies.....	273
0602383E	Biological Warfare Defense.....	87
0602304E	Cognitive Computing Systems .....	59
0603760E	Command, Control and Communications Systems .....	317
0601101E	Defense Research Sciences.....	1
0602716E	Electronic Technology .....	197
0603768E	Guidance Technology .....	431
0603764E	Land Warfare Technology .....	351
0605898E	Management Headquarters .....	439
0602715E	Materials and Biological Technology.....	173
0603766E	Network-Centric Warfare Technology .....	371
0602702E	Tactical Technology .....	99

## UNCLASSIFIED

Defense Adv Research Projects Agcy  
FY 2008/2009 RDT&E PROGRAM

EXHIBIT R-1

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

Date: 12 JAN 2007

Line No	Program Element Number	Item	Act	Thousands of Dollars				S E C
				FY 2006	FY 2007	FY 2008	FY 2009	
2	0601101E	Defense Research Sciences	01	127,893	145,239	152,622	156,242	U
		Basic Research		127,893	145,239	152,622	156,242	
11	0602303E	Information & Communications Technology	02	190,970	234,065	229,739	284,646	U
12	0602304E	Cognitive Computing Systems	02	159,244	180,003	179,728	202,439	U
13	0602383E	Biological Warfare Defense	02	132,814	112,814	99,137	106,982	U
16	0602702E	Tactical Technology	02	337,210	359,936	374,717	436,842	U
17	0602715E	Materials and Biological Technology	02	271,356	298,147	306,022	303,363	U
19	0602716E	Electronics Technology	02	220,011	239,370	213,529	219,844	U
		Applied Research		1,311,605	1,424,335	1,402,872	1,554,116	
32	0603286E	Advanced Aerospace Systems	03	50,272	80,474	86,385	95,703	U
33	0603287E	Space Programs and Technology	03	210,736	253,950	224,551	225,238	U
47	0603739E	Advanced Electronics Technologies	03	197,318	243,728	220,548	232,383	U
51	0603760E	Command, Control and Communications Systems	03	207,852	227,626	256,868	267,786	U
52	0603764E	Land Warfare Technology	03	107,171	44,805	24,711	32,612	U
53	0603765E	Classified DARPA Programs	03	156,107	151,025	188,188	210,801	U
54	0603766E	Network-Centric Warfare Technology	03	120,486	163,755	151,641	181,971	U
55	0603767E	Sensor Technology	03	167,962	188,781	196,462	219,407	U
56	0603768E	Guidance Technology	03	87,989	142,826	127,777	121,704	U
		Advanced Technology Development (ATD)		1,305,893	1,496,970	1,477,131	1,587,605	
149	0605502E	Small Business Innovative Research	06	75,061				U
157	0605898E	Management HQ - R&D	06	48,765	48,766	52,992	63,700	U
		RDT&E Management Support		123,826	48,766	52,992	63,700	

UNCLASSIFIED

PAGE D-37

iii

UNCLASSIFIED

Defense Adv Research Projects Agcy  
 FY 2008/2009 RDT&E PROGRAM

EXHIBIT R-1

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

Date: 12 JAN 2007

Line No	Program Element Number	Item	Act	Thousands of Dollars				S E C -
				FY 2006	FY 2007	FY 2008	FY 2009	
--	-----	----	---	-----	-----	-----	-----	-
169	0909999E	Financing for Cancelled Account Adjustments	06	1,500				U
		RDT&E Management Support		1,500				
				-----	-----	-----	-----	
Total Defense Adv Research Projects Agcy				2,870,717	3,115,310	3,085,617	3,361,663	

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	127.893	145.239	152.622	156.242	159.959	160.596	161.617	166.596
Bio/Info/Micro Sciences BLS-01	44.652	41.166	42.635	48.926	54.925	55.925	62.946	66.925
Information Sciences CCS-02	18.373	26.930	29.567	30.627	28.314	27.951	26.951	27.951
Electronic Sciences ES-01	28.563	35.860	37.588	32.751	31.752	31.752	27.752	27.752
Materials Sciences MS-01	36.305	41.283	42.832	43.938	44.968	44.968	43.968	43.968

**(U) Mission Description:**

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

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

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

**UNCLASSIFIED**

R-1 Line Item No. 2

Page 1 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E	

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

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

(U) **Program Change Summary:** *(In Millions)*

	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	133.308	150.690	153.460	156.242
Current Budget	127.893	145.239	152.622	156.242
Total Adjustments	-5.415	-5.451	-0.838	0.000
Congressional program reductions	0.000	-13.501		
Congressional increases	0.000	8.050		
Reprogrammings	-2.000			
SBIR/STTR transfer	-3.415			

(U) **Change Summary Explanation:**

FY 2006                      The decrease reflects SBIR/STTR transfer and a reprogramming of the Infotonics Research congressionally added funding to the Army.

**UNCLASSIFIED**

R-1 Line Item No. 2

Page 2 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E	

FY 2007            The decrease reflects the net effect of congressional program reductions to Bio Interfaces, Computer Science Study Group, Carbon Nanotube RF Devices, Nanoscale/Biomolecular and Metamaterials, Spin Dependent Materials and Devices, and Section 8106 Economic Assumptions; offset by six congressional adds in the areas of Next-Generation Protective Gear, Genomics, Alternative Futures, Defense Research Scholars program, Drug Discovery and Development and Material research.

FY 2008            The decrease reflects very minor program repricing.

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**  
R-1 Line Item No. 2  
Page 4 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research				<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project BLS-01				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Bio/Info/Micro Sciences BLS-01	44.652	41.166	42.635	48.926	54.925	55.925	62.946	66.925

**(U) Mission Description:**

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

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Bio Interfaces	3.900	5.000	7.960	10.925

(U) The Bio Interfaces program will support scientific study and experimentation, emphasizing the interfaces between biology and the physical and mathematical/computer sciences. This unique interaction will develop new mathematical and experimental tools for understanding biology in a way that will allow its application to a myriad of DoD problems. These tools will help exploit the advances in the complex modeling of physical phenomena such as Electro-Magnetic Pulse (EMP) and blast with biological tissues and cells in order to understand and prevent the deleterious effects of traumatic brain injury. It is also expected that understanding the fundamentals of biology will aid in developing tools to understand complex, non-linear networks and force structures.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project BLS-01	

- (U) Program Plans:
- Develop predictive biological models that take into account the materials and chemical properties of the brain to account for all blast effects including characteristics of the pressure wave, electromagnetic pulse, acoustics, etc.
  - Exploit understanding of predictive blast/brain models to develop methods for preventing and treating traumatic brain injury due to blast.
  - Demonstrate and validate novel mathematical tools for analyzing and interpreting complex data sets obtained from complex biological systems and behavior. Extend these tools to other problems of interest to DoD.
  - Develop new mathematics that predict fundamental biological processes across biological size and time scales.

	FY 2006	FY 2007	FY 2008	FY 2009
Biological Adaptation, Assembly and Manufacturing	9.000	11.300	9.175	11.000

(U) The Biological Adaptation, Assembly and Manufacturing program will examine the structure, function, and informational basis underlying biological system adaptation, particularly to harsh environments, and the factors employed by the organism to assemble and manufacture complex biological subsystems. The unique stability afforded biological systems in their ability to adapt to wide extremes of physical and endurance (e.g., heat, cold, and sleeplessness) parameters will be examined and exploited in order to engineer stability into biological systems required for the military (such as blood or other therapeutics). In addition, the fault tolerance present in biological systems will be exploited in order to assemble and manufacture complex physical and multi-functional systems, both biological and abiotic. Further activity in this area will investigate the adaptability of the brain to information processing and situational awareness. Applications to Defense systems include the development of chemical and biological sensors, and improved battlefield survivability of the warfighter.

- (U) Program Plans:
- Identify promising strategies in nature that allow organisms to survive under environmental extremes and adapt those strategies to other cells, tissues, organs and organisms, including platelets and red blood cells.
  - Understand how cells differentiate/heal into functional tissues using naturally occurring mechanisms and adapt these naturally occurring mechanisms to develop the ability to replace scarring with fully regenerated tissue and structure at a wound site.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project BLS-01	

- Determine which enteric bacteria that naturally occur in the gut can eliminate harmful bacteria and demonstrate that those bacteria can reduce the occurrence of diarrhea by 50%.
- Demonstrate the adaptation of bacteria to the digestion of cellulose in disaccharides to enable the ability to use fiber as nutrition and for the prevention of dysentery.
- Develop the fundamental understanding necessary to provide a single-step culture system that supports the differentiation of hematopoietic progenitor cells to mature megakaryocytes as a first step toward the reliable production of human blood products for battlefield use.

	FY 2006	FY 2007	FY 2008	FY 2009
Nanostructure in Biology	11.252	11.666	13.500	16.001

(U) The Nanostructure in Biology program will investigate the nanostructure properties of biological materials to better understand their behavior and accelerate their exploitation for Defense applications. This new information about biomolecules will provide important new leads for the development of threat countermeasures, biomolecular sensors and motors, and molecular interventions to maintain human performance in the battlefield. This program will also develop approaches to mathematically predict, a priori, the structure of biological materials, especially proteins, based on the desired performance. This will enable the rapid design of new biosensors against previously unknown threats and the design of advanced catalysts based on biological activity to produce new materials of interest to DoD (e.g., tailored explosives). The program will also create technology to reliably integrate nanoscale and microsystems payloads on insects that will extract power, control locomotion, and also carry DoD relevant sensors. In addition, research will be conducted in the interaction, at the nanoscale, of biotic and abiotic materials and functions, a critical aspect in the development of advanced prosthetics.

(U) Program Plans:

- Demonstrate image formation through the use of microchip-driven wire to simultaneously stimulate thousands of retinal neurons.
- Use nanostructured neural interfaces to develop an understanding of the neural information and algorithms used for biological visual processing (e.g., object recognition).

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project BLS-01	

- Demonstrate the ability to rapidly (hours as opposed to weeks or months) predict new protein structures that inactivate new biological pathogens or toxins.
- Demonstrate approaches for making enzymes that catalyze chemical reactions not performed by natural enzymes for the synthesis of chemicals of interest to the Department of Defense.
- Demonstrate locomotion control of insects using MEMS platforms consisting of ultrasonic projectors, pheromone ejectors, insect mechano-sensor activation, and visual presentation manipulation, neural, or muscular interfaces.
- Demonstrate power scavenging from insects via thermal-to-electric, and/or mechanical-to-electrical power conversion using embedded micro power generators.

	FY 2006	FY 2007	FY 2008	FY 2009
Human Assisted Neural Devices	12.000	12.000	12.000	11.000

(U) This program will develop the scientific foundation for understanding the language of the brain for application to a variety of emerging DoD challenges, including improving performance on the battlefield and returning active duty military to their units. This will require an understanding of neuroscience, significant computational efforts, and new material design and implementation. Key advances expected from this research include the ability to improve decision making in a variety of DoD applications including imagery analysis. In addition, this thrust will provide an understanding of how the brain adapts as it learns. This understanding will be translated into improved training approaches that allow transition from novices to expert in military tasks such as marksmanship to be accomplished with minimum effort and time. Techniques will be examined to extract these signals non-invasively, which, if successful, will have pervasive impact to on-going efforts, including Revolutionizing Prosthetics (PE 0602715E, Project MBT-02).

(U) Program Plans:

- Demonstrate that neural codes can control complex motor or sensory activity (e.g., reaching, grasping, manipulating, running, walking, kicking, digging, hearing, seeing, tactile) and that force and sensory feedback (positional, postural, visual, acoustic, and other) can be transferred back into the brain. Transition research to the Revolutionizing Prosthetics program.

**UNCLASSIFIED**

R-1 Line Item No. 2

Page 8 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project BLS-01	

- Explore new methods, processes, and instrumentation (e.g., Magnetoencephalography, optical, infrared, and radio frequency) for accessing neural codes non-invasively at appropriate spatiotemporal resolution to provide increased understanding of relationship between brain activity and function.
- Identify robust neural signals that respond to visually salient objects and demonstrate that those neural signals can be used to significantly (3x) improve throughput in visual analysis tasks such as imagery analysis compared to using an individual's visuomotor transformation (i.e., movement) based response.
- Investigate the underlying mechanisms of perception and cognition and use these to develop optimal approaches to radically improve neural plasticity in soldiers under stressful operational conditions.
- Develop fundamental understanding of the neural basis of learning in order to accelerate transition from novice to expert in the warfighter operational environment.

	FY 2006	FY 2007	FY 2008	FY 2009
BioComputational Systems	3.000	0.000	0.000	0.000

(U) The BioComputational Systems (BioCOMP) component used computation to understand the complexity of biology, and in turn used biology to enhance methods of computation. The BioCOMP program explored and developed computational models of bio-molecular processes in living cells that enabled a range of novel DoD capabilities for bio-agent threat assessment, force health protection, and bio-sensor design. The program also explored new biologically-inspired computing principles of robust information processing systems.

(U) Recently developed genomic information models of complex gene-protein interactions have enabled simulation, dynamic analysis, prediction and control of cellular processes. Based on these models, the program has developed Bio-SPICE (Simulation Program for Intra-Cell Evaluation), an open software framework providing innovative models and analysis tools. The extensible design of Bio-SPICE allows for adding, refining and customizing of the Bio-SPICE models and tools for specific cell processes.

(U) The program collaborated with several DoD client agencies including Defense Threat Reduction Agency (DTRA), U.S. Army Medical Research and Materiel Command (USAMRMC), Soldier Biological and Chemical Command (SBCCOM), Walter-Reed Army Institute for

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research		<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project BLS-01	

Research (WRAIR), Naval Medical Research Command (NMRC), the U.S. Air Force Toxicology program, and the Center for Disease Control and Prevention (CDC) for transition.

- (U) Program Plans:
- Developed a framework for describing and representing biological knowledge that spans data from the molecular (genomic, proteomic) to clinical level, and across organisms, to support deep and rapid knowledge extraction.
  - Implemented cutting edge learning and reasoning algorithms that act on vast amounts of biological, experimental and simulation data; and demonstrated rapid reasoning and knowledge-acquisition.

	FY 2006	FY 2007	FY 2008	FY 2009
Simulation of Bio-Molecular Microsystems (SIMBIOSYS)	4.000	0.000	0.000	0.000

(U) The Simulation of Bio-Molecular Microsystems (SIMBIOSYS) program developed methods and tools to simulate and design Bio-Molecular Microsystems to dramatically improve the interaction and integration of biological elements with synthetic materials. This was accomplished by exploring fundamental properties and compatibility of biological elements at the molecular surface level through experimental and theoretical analyses. Key phenomena under study included molecular recognition processes, signal transduction phenomena, and micro- and nano-scale transport of biological molecules. Engineering of biological systems was used to manipulate these fundamental characteristics and optimize the integration of biological elements with synthetic materials for information collection. Significant advancements in devices that utilize or mimic biological elements are being realized including sensors, computational devices and dynamic biological materials for force protection and medical devices.

- (U) Program Plans:
- Designed novel hybrid macro-molecular devices that form specific and controlled transducing functions at the molecular scale; demonstrated design of maltose binding proteins and ion channels with desired selectivity and sensitivity using computational tools.
  - Designed and demonstrated working devices that incorporate biological elements as sensors, actuators and computational devices.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research		<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project BLS-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Drug Discovery and Development Initiative for National Security	0.000	1.200	0.000	0.000

- (U) Program Plans:  
 – Effort will attempt to find promising new methods for discovering drugs to enhance national security efforts.

	FY 2006	FY 2007	FY 2008	FY 2009
Biomedical Engineering Initiative	1.500	0.000	0.000	0.000

- (U) Developed technologies to enable Biomedical Engineering.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**  
R-1 Line Item No. 2  
Page 12 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research				<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project CCS-02				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Information Sciences CCS-02	18.373	26.930	29.567	30.627	28.314	27.951	26.951	27.951

**(U) Mission Description:**

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

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Computer Exploitation and Human Collaboration	18.373	22.357	22.631	22.951

(U) The Computer Exploitation and Human Collaboration thrust supports research in broad areas of computational science having the potential for revolutionary advances in performance and other relevant metrics above and beyond extrapolations of current approaches. The research will yield significant advances in software, hardware, and computational systems that will allow warfighters and commanders of the future to interact in a natural way with computers, enable a new generation of collaboration methods and information acquisition, and provide intelligent seamless exchange of information in a world where computing devices are ubiquitous and heterogeneous. The thrust is exploring new human-machine interaction (HMI) paradigms where computing and communications systems reason about warfighter's and commander's goals and capabilities, and use this information to drive the interaction. Technical challenges include architectures for software agents; redesign of classical computer operating systems; secure exchange of information over insecure channels; robust, natural modes for increasing information and knowledge; and organizing both into easily retrievable, re-usable forms. Research is addressing breakthrough techniques for distilling key concepts from massive amounts of information and novel information presentation modes to provide concise, salient situational awareness. Work

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project CCS-02	

includes creation of powerful multi-agent systems and tools for effective decision-making and analysis in complex, multi-participant environments; high-performance, user-centered interfaces capable of understanding the warfighter and commander’s combined natural communication and activity patterns; and fundamental technologies for integrating information expressed in different modalities and formats, which is currently a bottleneck to timely military situational awareness.

(U) The Computer Exploitation and Human Collaboration thrust is exploring the fundamental science of interconnected systems to provide powerful mathematical tools for understanding the intrinsic properties and complexities of large-scale networks and other distributed systems. This foundational research is imperative for the future design of robust systems that break away from the established tradition of piece-meal patching of current infrastructures. The security of the nation depends on interconnected systems, such as data networks for the warfighter, the power grid, telecommunications systems, social and organizational networks, economic and financial systems and command and control structures. These networks can suffer dramatic failures. Such failures can potentially be prevented or controlled through a fundamental, quantitative understanding of the intrinsic properties of networks and development of mathematical tools. Additionally, deeper scientific foundations for what might be called “network understanding” will eventually generate dramatic new capabilities for the DoD while at the same time generating benefits for civilian applications. Overall, the research will provide vastly expanded power and improved interaction for a wide range of military tasks and environments. Currently the research is focused on the development of an overarching “Information Theory for Wireless Mobile Ad-Hoc Networks” (ITMANET). If this revolutionary kind of information theory can be developed, it will yield new mathematical tools applicable to other interconnected systems, offer practical guidance for developing the next generation of the DoD’s wireless networks, and moreover provide insight concerning the acquisition and deployment of nearer-term systems.

(U) Research on machine intelligence over the last two decades has revealed that many reasoning problems are inherently computationally complex, and in many cases, intractable. Solutions to these problems typically require either enormous computer resources, or simplification of the problem resulting in major sacrifices to accuracy. The Real-World Reasoning Thrust (REAL) is developing foundational technologies, heuristic approaches, and tools necessary to enable effective, practical machine reasoning about increasingly complex and large-scale problems. These technologies will aid commanders and warfighters in assessing the consequences of specific actions and strategies, and will help in predicting future results. The key technologies under investigation are effective, practical inferential reasoning in real-world situations with complexity and uncertainty; novel paradigms for learning while reasoning; integration of multiple reasoning paradigms; representation and reasoning with information that changes over time; reasoning about the goals of other agents; and appropriate metrics for measuring cognitive behavior and performance.

UNCLASSIFIED

R-1 Line Item No. 2

Page 14 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02	

(U) Advanced research in innovative computer architectures is required to develop a new generation of unique processor designs and hardware architectures that exploit advances in ultra-high performance processing to support DoD applications. Mainstream commercial computer architectures are, by necessity, both incremental and constrained: incremental so that existing corporate investments are not threatened, and constrained so that legacy business applications continue to run on the latest computers. From a commercial perspective, this interactive design approach makes economic sense, but it has negative security ramifications. The DoD’s increasing reliance on commercial hardware has had the unintended consequence of “leveling the playing field” with our adversaries. This effort will explore a new generation of processing architectures and critical functionality that could eventually provide revolutionary advances in processing capabilities, performance, and productivity thereby ensuring the U.S. continues to lead in computer architecture components that will form the foundations for the next wave of high performance embedded computing.

(U) Another area of research will take a fresh look at the design and implementation of cognitive architectures modeled after human cognition, combining principles from neuroscience and cognitive psychology with traditional artificial intelligence-based symbolic processing and knowledge representation. These efforts will draw on advances in neurophysiology and cognitive psychology to guide and augment traditional artificial intelligence (AI) approaches to learning, reasoning, memory, knowledge acquisition and organization, and executive functions. Designing software inspired by the brain’s processing schemes can offer leap-ahead advances in cognitive systems. This work has the potential to revolutionize a broad range of military applications through breakthrough performance of intelligent machines.

(U) Program Plans:

- Developed new machine learning algorithms that resulted in effectively doubling performance of personal cognitive assistants.
- Developed breakthrough technologies for multiple learning algorithms to share information and exchange training data even when the learning algorithms’ models are represented differently and potentially inconsistent.
- Developed methods for combining statistical and knowledge-based reasoning and learning algorithms.
- Defined fundamentally new computational models for reasoning, learning, memory and perception based on integrating recent scientific insights from neuroscience and cognitive psychology, plus mathematics and computer science.
- Derived a new theory of natural intelligence that is a hybrid of analog and digital processing in the brain.
- Developed adaptive multimodal processing techniques tailored to the user, task, and environment; and assessed performance and usability advantages within multimodal systems.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project CCS-02	

- Demonstrated, on problems of limited scope, a new learning-based algorithm that achieves a  $10^9$  speed-up in logical QBF (quantified Boolean formulae) reasoning.
- Demonstrated, on small problems, new reasoning algorithms that combine pruning, consistency models, and statistical sampling to decide on a course of action even when the state of the world is unknown.
- Determined, on small problems, that Nash equilibrium points could be identified in multi-party, mixed tactical/strategic settings, determining which action a commander should take and with whom to partner in a given situation.
- Initiated work by two university research teams to develop a revolutionary information theory for mobile ad-hoc networks (ITMANET) that will provide theoretical underpinnings and performance goals/limits for the next generation of DoD wireless networks as well as practical guidance for the acquisition and deployment of near-term systems.
- Assessed the state of the high performance computing independent software vendor (ISV) industry, surveying public and the private sector entities to determine the specific actions that can be taken to expand ultra-high performance computing usage across the private sector for national competitive gain, including the major drivers for usage, barriers and actions that can be taken to mitigate those barriers.
- Develop innovative algorithms for dramatically reducing the complexity and processing required for reaching conclusions in logical reasoning systems where the problems are of an operationally realistic scale and complexity.
- Develop reasoning algorithms that can analyze situations and decide on effective courses of action even when the exact state of the world is unknown (aka partial observability) on problems of realistic size and complexity.
- Develop strategic reasoning algorithms that analyze complex, multi-party, mixed tactical / strategic settings (like those found in modern warfare situations), and provide decision support to warfighters about who is partnered with whom and what posture might be taken with respect to these parties; where the problems are of realistic size and complexity.
- Develop an information theory for mobile ad-hoc networks that incorporates inherent system dynamics, multi-hop interactions, multi-user channels, protocol overhead, side information and feedback.
- Derive capacity limits for mobile ad-hoc networks using throughput-delay-reliability curves.
- Develop information-theoretic models for mobile ad-hoc networks employing emerging cooperative and distributed networking techniques.
- Establish multidisciplinary studies of large-scale interconnected systems drawn from the fields of information theory, complexity theory, adaptive systems, diffusion theory, group theory and social network analysis.

**UNCLASSIFIED**

R-1 Line Item No. 2

Page 16 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research		<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project CCS-02	

- Identify and evaluate non-conventional, revolutionary processing architectures to pursue breakthrough advancements in processing, performance, and productivity.
- Develop concepts for, and evaluate the feasibility of computational architectures and computing systems that monitor execution at run time, and dynamically optimize performance (e.g., with respect to caching, on-chip packet routing, etc.) on common applications.
- Provide program planning support for the DARPA Urban Challenge.

	FY 2006	FY 2007	FY 2008	FY 2009
Computer Science Study Group (CSSG)	0.000	4.573	6.936	7.676

(U) The Computer Science Study Group (CSSG) program funds emerging ideas from the computer science academic community to address the DoD's need for innovative computer and information science technologies; educate young principal investigators; acclimate a generation of researchers to the needs and priorities of the DoD, and enable 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.

(U) Program Plans:

- Establish a Computer Science Study Panel (CSSP) consisting of mentors from senior academic and military communities.
- Arrange seminars for CSSP participants, at sites around the country where participants can experience DoD computer and information science capabilities and shortcomings.
- Evaluate and approve proposals for major university research projects to conduct basic computer and information science and technology research, based on knowledge gained in CSSP meetings.
- Solicit co-funding from industry or interested government parties to continue successful university research projects.
- Develop a transition strategy with university participants and co-funding sources.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project CCS-02	

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Electronic Sciences ES-01	28.563	35.860	37.588	32.751	31.752	31.752	27.752	27.752

**(U) Mission Description:**

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

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
University Photonic Opto-Centers	9.000	6.452	2.010	0.000

(U) This program is dedicated to coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components. Such components are critical to enhancing the effectiveness of military platforms that provide warfighter comprehensive awareness and precision engagement. Topics researched include emitters, detectors,

**UNCLASSIFIED**

R-1 Line Item No. 2

Page 19 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project ES-01	

modulators and switches operating from infrared to ultraviolet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules. The University Photonic Opto-Centers Phase II program will facilitate and enhance interaction between the developers of cutting edge photonic device technology in the industry and academic researchers that exploit these devices for novel applications. Commercially co-funded, industrial participants benefit by getting feedback from potential users of their device technology as well as by ensuring that the graduates are trained in the latest device technologies.

(U) Program Plans:

- Evaluate novel methods for the design, fabrication and demonstration of chip-scale modules that integrate photonic, electronic and MEMS based technologies.
- Characterize the impact of these new technologies on applications in the areas of bio-photonics, optically addressed memory and on-chip optical interconnects.
- Fabricate and test individual chip-level sub-assemblies for later use in prototype development.
- Design and fabricate prototype modules using the system-on-a-chip approach.
- Develop testbeds capable of fully measuring and characterizing the mixed technologies implemented in the chip-scale components.
- Evaluate the performance characteristics of the prototype modules and determine the highest payoff dual use development paths.
- Identify and enlist industrial participants.
- Identify a common set of photonic devices most widely used/requested and make them immediately available for experimentation.

	FY 2006	FY 2007	FY 2008	FY 2009
Semiconductor Technology Focus Centers	10.000	10.000	10.000	10.000

(U) The Semiconductor Technology Focus Center Research program concentrates on exploratory and fundamental semiconductor research efforts that solve the most critical, long-term scaling challenges in the fabrication of high performance complex integrated circuits. This program will develop new design and fabrication approaches and will demonstrate technologies for reaching nano-scale device dimensions and hyper-scale integrated circuits that will meet future military needs. The Young Faculty Award (YFA) program will fund several 12-month research efforts focused on innovations that enable revolutionary advances in physics, materials, and devices.

**UNCLASSIFIED**

R-1 Line Item No. 2

Page 20 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01	

- (U) Program Plans:
- Develop efficient platform-based design methodologies and low latency interconnect technologies for complex integrated circuits that have application in high performance signal processing and communications systems.
  - Develop methods for physics-based simulations of performance of deeply scaled switching device structures and circuit architectures.
  - Develop the interface methodology for efficient handling and compilation of design object information for complex military integrated circuits.
  - Develop circuit architectures that reduce long interconnects.
  - Develop novel device fabrication and integration approaches for deeply scaled transistors and architectures for high performance mixed signal circuits for military needs.
  - Develop concepts and validation methods in one or combinations of the following areas: electronics, photonics, micro-electro-mechanical systems (MEMS), architectures and algorithms under the Young Faculty Award imitative.

	FY 2006	FY 2007	FY 2008	FY 2009
Molecular Photonics (MORPH) (formerly Supermolecular Photonics Engineering)	6.240	8.060	8.000	2.000

(U) Large dendritic and other highly branched organic molecules offer great potential for active photonic applications. Three-dimensional molecular structure and shape can be engineered to orient and immobilize optically active substituents to achieve much higher electro-optic activity than with traditional polymer systems. The ability to engineer molecular structure, shape, energy transport, and chemical composition offers the potential for distinct electronic energy level engineering without the traditional semiconductor crystal lattice. This will allow more freedom to tailor electromagnetic responses of individual molecules to achieve functionality not possible in semiconductors. Potential applications include: direct conversion of sunlight to power ("optical antenna"), inversion-less lasers and electromagnetically induced transparency (coherent organic emitters, and slow light materials), high performance photorefractive materials for signal processing and holographic memory, optical limiters and saturable absorbers as well as high performance modulators.

- (U) Program Plans:
- Model and simulate advanced structures for four classes of applications.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project ES-01	

- Improve modeling capability for predicting macro functionality from nanostructure.
- Emphasize chemical synthesis.
- Address parameters such as thermal stability, environmental chemistry tolerance (O<sub>2</sub>, H<sub>2</sub>O, etc) and photochemistry.
- Fabricate initial devices; continue modeling maturation.
- Final material synthesis, prototype device fabrications, characterization and demonstration.

	FY 2006	FY 2007	FY 2008	FY 2009
Photonics Technology Access Program (PTAP)	3.323	1.300	0.000	0.000

(U) The main goal of the Photonic Technology Access Program (PTAP) is to create a mechanism for providing the latest prototype optoelectronic devices and custom materials to systems researchers. The program seeks to build bridges between the device and systems research community, the university and industrial community and the teaching and research community.

(U) Program Plan:

- Employed a broker-supplier user model that has been previously tried for integrated circuits and micro-electro-mechanical systems to implement the program.
- Evaluated the number of device/material transactions implemented between users and suppliers.

	FY 2006	FY 2007	FY 2008	FY 2009
Quantum Entanglement Science and Technology (QuEST)	0.000	2.059	5.000	5.812

(U) The Quantum Entanglement Science and Technology (QuEST) program will explore the research necessary to create new technologies based on quantum information science. Technical challenges include loss of information due to quantum decoherence, limited communication distance due to signal attenuation, protocols, and larger numbers of quantum bits (Qubits) and their entanglement. A key challenge is to integrate improved single and entangled photon and electron sources and detectors into quantum computation and communication networks. Error

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research		<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project ES-01	

correction codes, fault tolerant schemes, and longer decoherence times will address the loss of information. Expected impacts include highly secure communications, algorithms for optimization in logistics, highly precise measurements of time and position on the earth and in space, and new image and signal processing methods for target tracking.

- (U) Program Plans:
- Explore the fundamental quantum systems including entanglement, decoherence, multipartite quantum systems.
  - Develop novel algorithms and protocols germane to quantum information science.
  - Investigate small quantum systems.

	FY 2006	FY 2007	FY 2008	FY 2009
MEMS Science and Focus Centers	0.000	7.989	9.486	8.771

(U) The MEMS Science and Focus Centers effort is seeking research by means of multi-performer (university/nonprofit/industry/other) focus centers dedicated to advancing a number of core technologies considered essential to the advancement of MEMS and Nano-Electro-Mechanical Systems (NEMS) technology for applications important to the Department of Defense (DoD). The fundamental technology areas of interest for the program are: Surface Physics, Noise Mechanisms, Reliability Physics, Scaling Physics, Microfluidics, Interconnections, Single-Molecule Methods, Modeling, Signal Processing Methods, and other areas.

- (U) Program Plans:
- Develop a fundamental understanding of the behavior of materials interfaces and associated reliability.
  - Fabricate non-lithographic MEMS.
  - Develop an understanding of fluidics on a nanoscale.
  - Develop MEMS enabled reconfigurable electronics.
  - Develop ultra-high Q nanoresonators.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research		<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project ES-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Semiconductor AlGaIn Injection Lasers (SAIL)	0.000	0.000	1.092	3.168

(U) The objective of SAIL (Semiconductor AlGaIn Injection Lasers) is to demonstrate lasers with ultraviolet emission in the wavelength range of 340 to 270 nm. These lasers will be based on heterostructures of Aluminum Gallium Nitride (AlGaIn). Such lasers do not exist at present. Once demonstrated, SAIL devices are expected to have applications in stand-off biodefense, such as point detection of aerosolized bio agents.

(U) Program Plans:

- Develop methods for preparing AlGaIn with low density of dislocations.
- Demonstrate effective p-type doping in AlGaIn with the AlN content of 60%.
- Fabricate injection lasers operating in the ultraviolet at 340 nm and 280 nm.
- Demonstrate stable and reliable operation of ultraviolet lasers at room temperature.

	FY 2006	FY 2007	FY 2008	FY 2009
Nanoscaled Architecture for Coherent Hyper-Optic Sources (NACHOS)	0.000	0.000	2.000	3.000

(U) This program will explore scaling rules for semiconductor laser sources. Such rules exist and are well understood in electronics but do not yet exist for photonic devices. Nanoscaled lasers would be useful in a wide range of applications, from close integration with electronics, on chip light sources, to single photon sources. The program idea is based on recent developments in heterostructured semiconductor nanowires (the gain medium), which establish the feasibility of forming lasers with diameters much smaller than the wavelength of light they produce. Simultaneously, advances in plasmonic structures, which support optical frequencies with x-ray like wavelength, make it possible to envision feedback structures (cavities) that are also shorter than the wavelength of light emitted from the cavity. The program goal will thus be to produce nanoscaled lasers with all three dimensions shorter than the wavelength of light. Important issues of beam shaping through antenna-like structures and powering via plasmonic structures will also be considered.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project ES-01	

- (U) Program Plans:
- Develop defect-free nanowire-based heterostructures.
  - Grow lithographically defined nanowire heterostructures.
  - Use photonic bandgap structures for feedback and coupling of light.
  - Establish and validate models for nanophotonics.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**  
R-1 Line Item No. 2  
Page 26 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Materials Sciences MS-01	36.305	41.283	42.832	43.938	44.968	44.968	43.968	43.968

**(U) Mission Description:**

(U) This project provides the fundamental research that underpins the development of advanced nanoscale and bio-molecular materials, devices and electronics for DoD applications.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Nanoscale/Biomolecular and MetaMaterials	11.000	12.000	15.057	17.500

(U) The research in this thrust area exploits advances in nanoscale and bio-molecular materials, including computationally based materials science, in order to develop unique microstructures and properties of materials. This includes efforts to develop the underlying physics for the behavior of materials whose properties have been engineered at the nanoscale (Metamaterials) level.

**(U) Program Plans:**

- Develop algorithmic approaches for predicting properties and structure of nano-scale and meta-materials using first principles/quantum mechanical methods with higher accuracy and reduced computational complexity.
- Couple the algorithmic approaches to methods that extract parameters for simulation of materials at larger spatial scales while conducting experiments to verify/validate the predicted properties at all spatial scales.
- Explore and exploit the underlying dualities between discrete and continuous computational methods to dramatically improve DoD computational abilities.
- Develop theoretical advances to characterize the propagation of random effects through differential equation models of electromagnetic material systems to allow interpolation, extrapolation, and hybridization of solutions to known systems to closely related “perturbed” systems.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research	<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project MS-01	

- Develop nanoscale material concepts (nano-generators) for harvesting available mechanical energy from a soldier's body and surrounding environment and convert it into usable electrical energy for micro sensors and devices such as chip scale atomic clocks (CSACs) or micro gas analyzers (MGAs).
- Develop nanotechnologies to enable the capability for low power, portable, nanoscale surface manipulation and nanoscale surface metrology for the purpose of encoding information on a wide variety of common surfaces.
- Develop advanced image detector materials to instantly and simultaneously detect one structural (computed tomography) and two functional (position emission tomography and single photon emission tomography) images of medical and life science interest.
- Demonstrate materials capability to allow multimodal imaging system with two orders of magnitude increased scan speed and detection for non-destructive testing and evaluation.
- Develop approaches for exploiting femtosecond laser pulses to generate multi-spectral imaging capable of examining nanostructured materials.
- Exploit nanotechnology to create a new class of previously inaccessible compositions for optical materials, including IR windows and transparent armor.

	FY 2006	FY 2007	FY 2008	FY 2009
Engineered Bio-Molecular Nano-Devices and Systems	8.155	10.433	12.775	11.000

(U) This program seeks to develop and demonstrate engineered bio-molecular nano-scale devices that enable real time observation and analysis of bio-molecular signals, thus enabling single molecule sensitivity with the simultaneous exploitation of the temporal domain (i.e., stochastic sensing). Arrays of such devices will enable an order of magnitude (10 to 100X) reduction in the time required for analysis and identification of known and unknown (engineered) molecules.

(U) Program Plans:

- Engineer hybrid biological/inorganic device architectures that optimize compatibility and information transfer between biological and non-biological materials with single molecule sensitivity.
- Develop new and innovative technologies in the areas of device architecture, design, interconnection, fabrication and integration of organic and inorganic materials to enable measurement of time constants of single molecule events.

**UNCLASSIFIED**

R-1 Line Item No. 2

Page 28 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01	

- Develop techniques to perform direct, dynamic, stochastic and combinatorial analysis of bio-molecular signals in order to characterize unique molecular signatures based on such analysis (i.e., automatic recognition) of various biological/chemical targets.

	FY 2006	FY 2007	FY 2008	FY 2009
Atomic Scale Materials and Devices (formerly Spin Dependent Mats. and Devices)	12.000	12.000	15.000	15.438

(U) This thrust examines the fundamental behavior of the physics of materials at the atomic scale in order to exploit this behavior for new devices and capabilities. A major emphasis of this thrust is to provide the theoretical and experimental underpinnings of a new class of semiconductor electronics based on spin degree of freedom of the electron, in addition to (or in place of) the charge. Not only will this class of electronics lead to novel and faster electronic devices, but it will also serve as one of the key technology enablers for quantum communications and quantum computation. In addition, this program will examine other novel classes of materials and phenomena such as plasmons or Bose-Einstein Condensates (BEC) that have the potential to provide new capabilities in the quantum regime.

(U) Program Plans:

- Demonstrate a variety of spin related devices such as a room temperature spin light emitting diode (LED), a spin transistor with significant gain and magnetic random access memory scaled down into the few nanometer bit size by replacing magnetic field switching with spin momentum transfer switching.
- Develop new storage class memories with 100 – 1000 times the density of MRAM, DRAM or FLASH using magnetic domain walls as the storage media and spin momentum transfer as the read and write protocol.
- Investigate the magnetic and electronic characteristics of surface plasmons for the creation of metal/dielectric interfaces for coupling between photonic and electronic/spin states.
- Demonstrate atom-chip BEC lifetimes of >100ms and quasi-continuous BEC with 2000 atoms/pulse and >20% duty cycle.
- Demonstrate rotationally sensitive atom interferometer using optical readout in magnetic waveguides; establish sensitivity.
- Develop an optical lattice emulator (OLE) of strongly correlated systems to enable a new approach to the design of technologically important materials (e.g., high-temperature superconductors and ferromagnetic semiconductors), and serve as an early platform for synthesis of novel exotic states of matter (e.g., supersolids).

**UNCLASSIFIED**

R-1 Line Item No. 2

Page 29 of 32

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research		<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project MS-01	

- Develop fundamental technologies to enable a compact all-optical clock, including the frequency standard and associated electronics, that would produce a time output with accuracy and stability in excess of any transportable clockwork currently in existence.
- Explore fundamental behavior of nanostructured materials that display quantum and/or non-equilibrium behavior.

	FY 2006	FY 2007	FY 2008	FY 2009
Comparative Genomics for National Security Goals	1.500	1.650	0.000	0.000

- (U) Program Plans:
- Develop new approaches for examining prognostic epidemiology using comparative genomics.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Materials for Quantum Computing	2.650	0.000	0.000	0.000

- (U) Program Plans:
- Developed materials that enabled the instantiation of quantum computing concepts.

	FY 2006	FY 2007	FY 2008	FY 2009
PBO	1.000	0.000	0.000	0.000

- (U) Program Plans:
- Researched the application of PBO (Polyphenylene benzobisoxazole) in the development of non-flammable and lightweight materials.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research		<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project MS-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Materials Research Institute	0.000	2.200	0.000	0.000

- (U) Program Plans:
- This effort will focus on the development and demonstration of hybrid sensors for chemical and/or biological agent detection for national security. In particular, sensors made from metal oxide nanoparticles and nanowires will be explored.

	FY 2006	FY 2007	FY 2008	FY 2009
Next Generation Protective Gear for Small Arms Threats	0.000	1.000	0.000	0.000

- (U) Program Plans:
- Explore next generation protective gear for small arms threats.

	FY 2006	FY 2007	FY 2008	FY 2009
Alternative Futures at the Range-Complex Level for the Southwest U.S.	0.000	1.000	0.000	0.000

- (U) Program Plans:
- Explore alternative Range-Complex Level Futures in the Southwestern part of the U.S.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA1 Basic Research		<b>R-1 ITEM NOMENCLATURE</b> Defense Research Sciences PE 0601101E, Project MS-01	

	FY 2006	FY 2007	FY 2008	FY 2009
John H. Hopps Defense Research Scholars Program	0.000	1.000	0.000	0.000

- (U) Program Plans:  
 – Support the John H. Hopps Defense Research Scholars Program.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

<b>JRDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research			<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E					
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	190.970	234.065	229.739	284.646	263.389	195.370	188.370	183.370
High Productivity, High-Performance Responsive Architectures IT-02	87.458	77.952	65.913	105.000	84.019	38.000	33.000	33.000
Information Assurance and Survivability IT-03	48.887	77.256	92.403	106.432	106.277	84.277	82.277	77.277
Language Translation IT-04	54.625	78.857	71.423	73.214	73.093	73.093	73.093	73.093

**(U) Mission Description:**

(U) The Information and Communications Technology program element is budgeted in the applied research budget activity because it is directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The High Productivity, High-Performance Responsive Architectures project is developing high-productivity, high-performance computing hardware and the associated software technology base required to support future critical national security needs for computationally-intensive and data-intensive applications. These technologies will lead to new multi-generation product lines of commercially viable, sustainable computing systems for a broad spectrum of scientific and engineering applications; it will include both supercomputer and embedded computing systems.

(U) The Information Assurance and Survivability project is developing the technology required to make emerging information system capabilities (such as wireless and mobile code/mobile systems) inherently secure, and to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are attacked, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E	

(U) The Language Translation project will develop and test powerful new Human Language Technology that will provide critical capabilities for a wide range of national security needs. This technology will enable systems to a) automatically translate and exploit large volumes of speech and text in multiple languages obtained through 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 distillation; d) enable exploitation of captured, foreign language hard-copy documents.

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	195.991	242.852	249.651	247.146
Current Budget	190.970	234.065	229.739	284.646
Total Adjustments	-5.021	-8.787	-19.912	37.500
Congressional program reductions	0.000	-8.787		
Congressional increases	0.000			
Reprogrammings	0.000			
SBIR/STTR transfer	-5.021			

(U) **Change Summary Explanation:**

FY 2006	The decrease reflects SBIR/STTR transfer.
FY 2007	The decrease reflects congressional program reductions to High Productivity Computing System, Security-Aware Systems, Automated Speech and Text Exploration, and a reduction for Section 8106 Economic Assumptions.
FY 2008/09	The FY 2008 reduction and \$20M of the FY 2009 increase reflect budgetary rephasing necessary to match the milestone payment schedules in the recently awarded High Productivity Computing System contracts. Increased activity in the Information Assurance project accounts for the balance of the FY 2009 increase.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research				<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-02				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
High Productivity, High-Performance Responsive Architectures IT-02	87.458	77.952	65.913	105.000	84.019	38.000	33.000	33.000

**(U) Mission Description:**

(U) The High Productivity, High-Performance Responsive Architectures project is developing high-productivity, high-performance computing hardware and the associated software technology base required to support future critical national security needs for computationally-intensive and data-intensive applications. These technologies will lead to new multi-generation product lines of commercially viable, sustainable computing systems for a broad spectrum of scientific and engineering applications; it will include both supercomputer and embedded computing systems. The thrust will ensure accessibility and usability to a wide range of application developers, not just computational science experts. This project is essential for maintaining the nation’s strength in both supercomputer computation for ultra-large-scale applications and embedded systems for surveillance and reconnaissance.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Responsive Computing Architectures	87.458	77.952	65.913	105.000

(U) Within this thrust, the ongoing High-Productivity Computing Systems (HPCS) program will enable stockpile stewardship, weapons design, cryptanalysis, weather prediction, and other large-scale problems that cannot be addressed with today’s computers. The goal of this multi-agency program is to develop revolutionary flexible and well-balanced computer architectures that will deliver high performance with significantly improved productivity for a broad spectrum of applications within a vendor’s product family.

(U) It is extremely difficult to program today’s high-performance computers; even for expert programmers, these systems present a significant challenge. The programming of such large systems must be made much easier so that programmers and scientists with minimal computer skills can harness the power of high-performance computers. As the number of processors increases to 100,000 and beyond, it is difficult not only to

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-02	

develop application codes, but also to debug and optimize them, since tools that will help are designed for small-scale systems (10's of processors). The area of user productivity is where HPCS is focusing significant effort. The HPCS technology development plan is being executed in three phases that will extend to the end of this decade. The three phases are (I) concept design study, (II) research and development, and (III) system development, resulting in large-scale prototypes.

(U) Initiated in 2002, the DARPA HPCS program is responsive to a strategy developed in conjunction with the U.S. national security community. The ultimate goal of the HPCS program is to create a new generation of economically viable high productivity computing systems for the national security and industrial user communities. High productivity computing is a key technology enabler for meeting our national security and economic competitiveness requirements. The HPCS program has now moved into the third and final phase, with a down-select from three vendors to two. In Phase III of the HPCS program, the two winning vendors will complete the designs and technical development of very large (petascale) productive supercomputers, with delivery of prototype systems in 2010-2011. DARPA funding is sufficient to cover the contractual requirements of one of the two selected vendors. NSA and DOE, partners with DARPA in this program, are funding the second vendor.

(U) Other areas of research that will contribute to higher productivity of DoD applications include: 1) research using commodity components to efficiently execute specialized applications; 2) research into reverse compilation techniques; and 3) research to develop high-productivity, kilo-core processors and new programming models. This research area is considered a necessity for the future of embedded computing. Research in this area may ensure the scalability to tens-of-thousands of homogeneous and heterogenous cores and processors, minimize power consumption, and enable transparent use by non-expert programmers.

(U) Program Plans:

- Completed a focused industry R&D Engineering Phase II effort that evaluated, simulated, and prototyped components of the innovative HPCS system architectures selected from the Phase I concept studies.
- Released alpha "value based" productivity metrics and benchmarks to guide future program research and development activities.
- Performed a critical technology assessment and prototype engineering readiness review of the Phase II HPCS petascale systems and their viability for implementation in the 2010-2011 timeframe. Evaluated alternative balanced system architectures.
- Performed a down-select from the Phase II participants.
- Initiate prototype development (Phase III) of a high-end high-productivity petascale computing system.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-02	

- Perform research and development on parallel programming languages and/or development environments that increase user productivity.
- Create a common development environment and supporting technologies that will allow efficient application development, implementation, and execution on heterogeneous computer architectures.
- Develop the technology to extract and recreate (reverse compile) a high-level implementation of an application from existing executable or large legacy application source code.
- Create the development environment (tools, compilers, libraries, etc.) that will allow efficient implementation of performance-critical applications using the capabilities of high performance, specialized commercial commodity devices.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

R-1 Line Item No. 11

Page 5 of 26

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 11

Page 6 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research				<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Information Assurance and Survivability IT-03	48.887	77.256	92.403	106.432	106.277	84.277	82.277	77.277

**(U) Mission Description:**

(U) This project is developing the technology required to make emerging information system capabilities (such as wireless and mobile code/mobile systems) inherently secure, and to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are attacked. The technologies will also lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites. Technologies developed under this project will be exploited by all the projects within this program element, and those in the Command, Control, and Communications program element (PE 0603760E), the Network-Centric Warfare Technology program element (PE 0603764E), the Sensor Technology program element (PE 0603767E), the Guidance Technology program element (PE 0603768E), and other programs that satisfy defense requirements for secure, survivable, and network centric systems.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Next Generation Core Optical Networks (CORONET)	2.754	7.463	11.500	18.500

(U) The Next Generation Core Optical Networks (CORONET) program will revolutionize the operation, performance, security, and survivability of the United States' critical inter-networking system by leveraging technology developed in DARPA photonics component and secure networking programs. These goals will be accomplished through a transformation in fundamental networking concepts that form the foundation upon which future inter-networking hardware, architecture, protocols and applications will be built. Key technical enablers that will be developed in this thrust include: (1) network management tools that guarantee optimization of high density wavelength-division-multiplexed optical channels, such as those provided by wavelength division multiplexing; (2) creation of a new class of protocols that permit the cross-layer communications needed to support quality-of-service requirements of high-priority national defense applications; and (3) demonstration of novel

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

concepts in applications such as distributed and network based command and control, intelligence analysis, predictive logistics management, simulation and scenario enhanced decision-making support for real-time combat operations, and assured operation of critical U.S. networking functions when faced with severe physical layer attack. These network-based functions will support the real-time, fast-reaction operations of senior leadership, major commands and field units.

(U) The All-Optical Transmission and Switching Systems for the Next-Generation Core Optical Networks program will develop the technology to realize a dynamic multi-terabit circuit-switched optical core for the next-generation packet switched IP network through: (1) the elimination of data-flow bottlenecks and the enhancement of network scalability through the creation of optical network hardware that minimizes the occurrence of need for optical-to-electrical-to-optical conversions; (2) greatly increased network capacity through the use of more efficient fiber-optical transmission techniques; and (3) implementing highly dynamic optical networking through the creation of high capacity, efficient, agile all optical switching platform.

(U) Program Plans:

- Next Generation Core Optical Networks
  - Develop the architectures and define the network elements for a fast reconfigurable optical core network.
  - Develop protocols, algorithms and the network control and management architecture for a core optical network.
  - Model and simulate a dynamically reconfigurable multi-terabit core optical network.
  - Develop the network control and management software such that the final product can be transitioned and implemented in current commercial core optical networks and, ultimately, in government core networks.
  
- All-Optical Transmission and Switching Systems
  - Develop and demonstrate an efficient fiber-optical transmission technique to enable several-fold increase in fiber capacity.
  - Develop architecture design and fabrication of an optical switch capable of fast switching of wavelength and sub-wavelength grooming suitable for high-capacity and low-latency, real-time applications, with data format independence.
  - Develop national-scale multi-terabit network testbed to test and demonstrate the CORONET hardware and software capabilities.

UNCLASSIFIED

R-1 Line Item No. 11

Page 8 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

	FY 2006	FY 2007	FY 2008	FY 2009
Dynamic Quarantine of Computer-Based Worms	18.643	19.671	13.817	9.432

(U) The goal of the Dynamic Quarantine of Computer-Based Worms program is to develop defenses for U.S. military networks against large-scale malicious code attacks such as computer-based worms. As the U.S. military pushes forward with network-centric warfare, terrorists and other nation-states are likely to develop and employ malicious code to impede our ability to fight efficiently and effectively. This program will develop the capability to automatically detect and inoculate DoD networks against computer-based worm attacks. Additionally, the program will develop and refine technologies for Defense Against Cyber Attacks on Mobile Ad hoc Network Systems (DCAMANETS). This effort will provide defenses that can sense failures and attacks on military tactical wireless networks and auto-reconfigure in real-time to provide continuous service of mission-critical activities. This program will continue to develop technology to ensure wireless mobile network centric warfare systems are able to fulfill their mission in spite of runtime hardware/software failures and cyber attacks. This program will develop technology to reconfigure the network, nodes, and platforms for optimal mission execution as a result of changes that may occur in the trustworthiness of the network. This program will also assess the comparative strength of different architectural solutions.

(U) Program Plans:

- Refined automatic detection and quarantine mechanisms.
- Developed and transitioned off-line malicious code analysis capabilities.
- Developed an automated mobile wireless testbed that emulates operational environments.
- Developed and tested host and network-based detection and quarantine sensors/actuators for MANET systems.
- Test auto-quarantine capabilities against sophisticated threats.
- Inoculate hosts against reinfection by the same or slightly modified worms.
- Develop application re-provisioning services for failed nodes.
- Verify integrated system capabilities.
- Assess the relative performance of different architectural solutions.

**UNCLASSIFIED**

R-1 Line Item No. 11

Page 9 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

	FY 2006	FY 2007	FY 2008	FY 2009
Trustworthy Systems	5.711	10.299	12.800	15.000

(U) The goal of the Trustworthy Systems program is to provide foundational trustworthy computer platforms for Defense Department computing systems. This program seeks to develop technologies such as novel computer processing architectures, hardware, firmware, or microkernels to guarantee network and workstation security as well as data integrity for secure applications. This technology will protect Defense systems from a wide-range of software problems, ranging from worms and Trojan horses, to just plain bug-ridden software. Transition targets include weapons platforms, flight control systems, and enterprise software systems. The transition customers are Joint Task Force-Global Network Operations (JTF-GNO) and the DoD Services through the Enterprise Security Steering Group (ESSG).

(U) Initially, an Information Assurance (IA) Transition effort in this project will identify, develop, and transition key information assurance research technologies to DoD networks, filling gaps in commercial off-the-shelf (COTS) tool coverage. Specifically, previously-funded DoD research technologies will be identified, matured, evaluated, and deployed on select DoD networks as a testbed for developmental integration testing. This program provides a framework for advocates of other technologies to be similarly considered for deployment to DoD networks. The desired final output of the program is a more secure DoD network, providing improved protection against current and future threats.

(U) Program Plans:

- Trustworthy Systems
  - Develop hardware, firmware, and microkernel architectures as necessary to provide foundational security for operating systems and applications.
  - Develop tools to find vulnerabilities in complex open source software.
  - Develop scalable formal methods to verify complex hardware/software.
  - Research network-sensitive approaches, such as thermodynamic based concepts, to monitor, and trustworthy controllers to control, how and when information is disseminated across the network based on network performance, load, criticality, and target capacity.
  - Investigate the use of new virtual machine hardware architectures to develop a feedback loop that enables the host to monitor and control its behavior in the presence of untrustworthy software.

**UNCLASSIFIED**

R-1 Line Item No. 11

Page 10 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

- Integrate these tools and methodologies into standard DoD systems through the ESSG.
- Information Assurance (IA) Transition
  - Matured the technologies to the point they can be operationally tested.
  - Tested and evaluated secure hardware designs, software architectures, and code assessment technologies.
  - Deployed technologies on pilot network.
  - Identify key IA technologies for transition.

	FY 2006	FY 2007	FY 2008	FY 2009
DARPA Future Information Assurance Initiatives	3.150	5.603	8.250	10.500

(U) The DARPA Future Information Assurance Initiatives will identify promising technologies to enable remote C<sup>4</sup>ISR warfighting. Sophisticated computing capabilities currently available in desktop workstation and server systems are moving to mobile wireless embedded systems that communicate over low bandwidth self-organizing tactical networks. As a result, the spectrum of devices the U.S. military must protect is increasing from wired and wireless tactical and garrison computers to include a wide array of small mobile devices. With foreign production of information technology components increasing and adversaries seeking to leverage cyber warfare as the Achilles' heel of current and future U.S. military systems; the U.S. military must have the ability to withstand, operate through, and counter increasingly effective cyber attacks while reducing the manpower required. Other distinct programs within this project will be created to pursue promising technologies as they are identified for further focused development. Included in this initiative is the development of secure, efficient network protocols to exploit tomorrows network-centric technologies such as networked weapons platforms, mobile ad hoc networks, and end-to-end collaboration (vice client-server paradigm).

- (U) Program Plans:
- Develop automatic techniques to modify computer applications to add information assurance properties (e.g. confidentiality, authentication, and others).

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

- Develop the ability to protect the core signaling and control of converged networks running voice over IP (VOIP), wireless, voice, and data networks in enterprise telecommunications.
- Identify and authenticate hosts on the network and allow these hosts to discover their network's operating attributes.
- Develop a family of distributed, autonomous security devices to deal with asymmetric traffic on wide area networks.
- Develop a secure, efficient network routing protocol for tomorrow's weapon, logistic, and command and control requirements.
- Develop a wireless protocol that securely provides location, authentication, and communications in a practical manner.
- Investigate new approaches to network security that scale with increased data rates and address spaces of future networks.
- Develop unified routing and discovery protocols that address autonomous systems, transport domains and security domains in order to support the Global Information Grid (GIG) multi-scale network-of-networks architecture.
- Enable the ability to detect and respond to next generation malicious software including stealthy "backdoors" to the operating system kernel and networks of compromised computers.

	FY 2006	FY 2007	FY 2008	FY 2009
Control Plane	5.752	6.956	6.296	5.500

(U) The Control Plane program will improve end-to-end network performance between the Continental United States (CONUS) operating base and forward deployed tactical units. Control Plane seeks to develop the ability for individual hosts (end-points) to learn essential characteristics about the network, allowing the hosts to shape the network and network traffic to optimize network loading, prioritize traffic, and create communities of interest. Additionally, when multiple network paths are available, hosts will be able to choose the best path/community or simultaneously transmit over multiple paths/communities. This technology will support the Defense Department's Global Information Grid concept of operations.

(U) Program Plans:

- Develop hardware and software mechanisms to improve end-to-end wide-area network performance between the Continental United States (CONUS) operating base and forward deployed tactical units.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

- Develop the ability of individual hosts (end-points) to learn essential characteristics about the network path between themselves and their transmission partners through network query protocols.
- Investigate authentication protocols for secure transmission of network performance information.
- Develop the ability of hosts to learn about more than one possible transmission path, other hosts' abilities and purpose, and form communities of interest which suits their collective needs best.
- Develop the ability of hosts to simultaneously use multiple network paths for the same data transmission with the same partner, increasing communications speed and reliability.

	FY 2006	FY 2007	FY 2008	FY 2009
Wide Area Network (WAN) Monitoring	2.408	4.300	3.000	0.000

(U) The Wide Area Network (WAN) Monitoring effort seeks to develop distributed network monitoring capabilities and devices that can be used to identify, characterize, enable, optimize, visualize, and protect the WANs that compose the DoD enterprise Global Information Grid (GIG). This program will develop advanced capabilities to monitor the WANs that will comprise the GIG to detect malicious behavior, routing problems, or compromised mission capability. Goals include improved detection and false-alarm performance over conventional intrusion detection systems and scalability to the larger networks. This technology will support the Department of Defense's Global Information Grid Information Assurance Technical Framework.

- (U) Program Plans:
- Investigated algorithms that quickly characterize various host's security configurations, identity, and classification as well as measure the type and quantity of information exchange.
  - Studied technologies that identified operational impacts of network issues and suggested an alternative course of action to continue operations.
  - Analyzed technologies to synthesize and visualize extremely large networks to improve leadership's situational awareness at the enterprise level.
  - Researched high-throughput hardware to implement the algorithms at the sensor layer.

**UNCLASSIFIED**

R-1 Line Item No. 11

Page 13 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

- Investigate low-latency networks to collect the information.
- Investigate high-speed analyzers to assimilate the data and detect perturbations.
- Research integrating and testing components in a fully functional configuration.

	FY 2006	FY 2007	FY 2008	FY 2009
Spread Spectrum Networking	0.000	2.900	5.000	4.000

(U) Spread spectrum communication technology will significantly improve security against a variety of network attacks and identification profiles by spreading energy over a broad bandwidth, thereby providing an adversary with a signal which is both difficult to detect, as well as difficult to jam without using significant resources. This program expands these same goals, by addressing not just the physical layer but also the entire network stack. Similar to frequency-hopping spread spectrum, the approach of this program is to develop and demonstrate algorithms that provide hopping between Internet Protocol (IP) addresses and then expanding to hopping between different permutations of layer 1-3 protocols. The utility is to provide significantly improved security against a variety of network attack and identification profiles.

(U) Program Plans:

- Determine the most effective cross layer spreading techniques through analysis and simulation.
- Implement these techniques on relevant platforms.
- Demonstrate the effectiveness of these techniques against network attack.

	FY 2006	FY 2007	FY 2008	FY 2009
Control-Based Mobile Ad-Hoc Networks (CBMANET)	4.500	8.099	11.560	14.500

(U) An outgrowth of the Trustworthy Systems and the DARPA Future Information Assurance Initiatives, the Control-Based Mobile Ad-Hoc Networks (CBMANET) program will develop an adaptive networking capability that dramatically improves performance and reduces life-threatening communication failures in complex communication networks. In order to develop this new capability, the initial focus is on tactical

**UNCLASSIFIED**

R-1 Line Item No. 11

Page 14 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

mobile ad-hoc networks (MANETs). MANETs are composed of interdependent nodes based on interdependent system layers. Each node exposes tens to hundreds of configurable parameters that must be continuously adapted due to variable tactical factors such as mission profile, phase, force structure, enemy activity, and environmental conditions. The complexity of this high-dimensional, adaptive, constrained, distributed network configuration problem is overwhelming to human operators and designers and has root causes in the historically wireline-oriented networking paradigms. Today's commercial trends are not aimed at supporting the DoD's extreme deployments or unique applications. This program will take on the ambitious goal of researching a novel protocol stack that supports integrated optimization and control of all network layers simultaneously. Key technical challenges include scalable design, stability, and convergence. These challenges are particularly difficult in a distributed setting with partial and uncertain information, high communications overhead, and high probability of link failure. To address this problem, the CBMANET program will exploit recent optimization-theoretic breakthroughs, recent information-theoretic breakthroughs, and comprehensive cross-layer design to develop a network stack from first principles with specific attention to support for DoD applications such as multicast voice and situation awareness.

(U) Program Plans:

- Design and develop novel protocol architecture from first principles in information theory and optimization theory.
- Design and demonstrate protocols based on network coding that vastly improve performance in extreme conditions.
- Design and demonstrate cross-layer protocols and adaptive control capabilities to drive resource allocation more efficiently.
- Design novel control interfaces to support DoD-relevant applications such as multicast and situation awareness.
- Design appropriate interfaces between the novel network stack and the physical radio platforms to support cross-layer optimization.
- Perform quantitative analysis and trade studies to understand the degree of performance offered by the novel network stack.
- Research the requirements for a radio hardware platform to optimally support the novel network stacks.

	FY 2006	FY 2007	FY 2008	FY 2009
Security-Aware Systems	5.969	11.965	14.680	19.000

(U) The Security-Aware Systems thrust will develop and advance a variety of potentially promising technologies to enable the military to field secure, survivable, self-monitoring, self-defending network centric systems. Today's military software systems are brittle in the face of changing

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

requirements. They are vulnerable to skilled attackers who develop creative and unpredictable strategies, and are increasingly dependent on software produced in and/or “outsourced” to potentially hostile nations. Misconfiguration accounts for most security failures in internet services and poses a serious risk to military systems. This program will develop security aware systems that will avoid brittleness and vulnerability, due to their ability to reason about their own security attributes, capabilities and functions with respect to specific mission needs. These systems will also dynamically adapt to provide desired levels of service while minimizing risk and providing coherent explanations of the relative safety of service level alternatives. These systems will bolster the reliability and security of critical open source software systems by reducing vulnerabilities and logic errors, and providing state-of-the-art software analysis techniques augmented with cognitive decision-making techniques with the ultimate goal of applying these systems on to the Global Information Grid. The Security-Aware Systems thrust consists of two programs, Applications Communities (AC) and Self Regenerative Systems (SRS).

- The Application Communities (AC) program is a major effort funded within the Security-Aware Systems program. The program will develop technologies to protect DoD information systems that employ commercial software applications against cyber attack and system failure by developing collaboration-based defenses that detect, respond to, and heal with little or no human assistance. The program will leverage advances in information assurance research programs to create a new generation of self-defending software that automatically responds to threats, and provides a comprehensive picture of security properties, displayed at multiple levels of abstraction and formality. This capability will bring intelligent security adaptation to DoD systems and make security properties and status more apparent to decision makers. AC technology will enable collections of similar systems to collaboratively generate a shared awareness of security vulnerabilities, vulnerability mitigation strategies, and early warnings of attack. AC will revolutionize the security of military information systems and reduce the threat from stealthy intrusion of critical systems and/or denial of service attacks.
- The Self-Regenerative Systems (SRS) program will design, develop, demonstrate and validate architectures, tools, and techniques for fielding systems capable of adapting to novel threats, unanticipated workloads and evolving system configurations. The technology development of this program will employ innovative techniques like biologically-inspired diversity, cognitive immunity and healing, granular and scalable redundancy, and higher-level functions such as reasoning, reflection and learning. These technologies will make critical future information systems more robust, survivable and trustworthy. The SRS program will also develop technologies to mitigate the insider threat. The program will combine the SRS technology foundations in an exemplar military system that learns, regenerates itself, and automatically improves its ability to deliver critical services over time. SRS-enabled systems will be able to reconstitute their full functional and performance capabilities after experiencing accidental component failure, software error, or even an intentional cyber-

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

attack. These systems will also show a positive trend in reliability, actually exceeding initial operation capability and approaching a theoretical optimal performance level over long periods while maintaining robustness and trustworthiness attributes. This program was formerly funded under PE 0602304E, Project COG-01. This move represents a consolidation of information assurance activities.

(U) Research efforts within this thrust will explore two additional areas. The first is research that addresses vulnerabilities, missions and threats in computer abstract-model reasoning. Resulting technology will enable current systems to generate vulnerability reports ranked by probable impact of a failure/attack on the mission. This would include developing a cognitive agent that understands the structure of a defending system and its mission, hypothesizes goals of attackers, and generates plans on-the-fly to maintain mission success. A second area will explore practical advanced software engineering technology for building flexible systems that allow new features to be added via “interposition” between existing features, with guaranteed levels of reliability and security.

(U) Program Plans:

- Developed an Application Community (AC) system architecture and demonstrated an initial working prototype.
- Demonstrated community-enabled learning of program behavioral constraints which can be used to protect and repair software systems.
- Develop techniques to collaboratively diagnose and respond to problems (e.g., attacks or failures that threaten a mission) in groups of military systems.
- Develop techniques to summarize security policy and status so the descriptions produced by AC can be understood without omitting critical details.
- Develop static and dynamic source code analysis techniques (e.g., data- and control-flow-based techniques, model-checking, strong typing) to relate software module structures and runtime state with the representation of security properties/configurations.
- Demonstrate self-explanation techniques in which systems explain their critical security properties and status in a manner that is understandable to a variety of managing software components and human operators.
- Develop test and validation regimes to assess the protection mechanisms of security products and certify protection to quantifiable levels based on a scientific rationale.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Information and Communications Technology PE 0602303E, Project IT-03	

- Develop measures to quantitatively characterize various dimensions of security (availability, integrity, confidentiality, authentication, and non-repudiation), fault tolerance, and intrusion tolerance and demonstrate the theory's relevance by applying it to a realistic exemplar system.
- Develop technologies to enable systems to heal automatically.
- Develop capability to infer intentions of military systems operators in time to preempt malicious insider attacks.
- Tie the Self Regenerative Systems (SRS) technologies with a cognitive framework that allows feedback and cognitive control of the overall system's survivability posture.
- Develop techniques for practical construction of extensible software and analysis techniques for predicting the effects of new functionality inserted into a system.
- Develop a representation of intrusion tolerance domain knowledge in a machine processable form.
- Develop the capability for the system to reason effectively when faced with low confidence/non-trusted information.

	FY 2006	FY 2007	FY 2008	FY 2009
SuperMAC	0.000	0.000	3.000	5.000

(U) Multiple Access Control (MAC) protocols drive the performance of wireless ad hoc networks by allocating radio frequency (RF) channel access among competing users. Traditional MAC approaches, however, provide limited RF bandwidth efficiency and network scalability resulting from a lack of knowledge of the RF environment or dynamic low-level network parameters. Existing MAC algorithms attempt to account for the information gap by making worst-case assumptions of RF channel, transceiver, modem, and network parameters rather than adapting to the actual situation, leading to network inefficiencies.

(U) The objective of the SuperMAC program is to design MAC algorithms that use "right-case" instead of worst-case assumptions to achieve greater than an order magnitude improvement in wireless ad hoc network performance. Many of the unknown RF environment parameters actually can be measured directly and derived from higher-level network parameters. SuperMAC algorithms will attempt to exploit this by dynamically measuring observable parameters, such as RF propagation delay, link margin, modem state change time, and number of network neighbors, of the radio transceiver and the environment. The observable physical RF parameter values will be used to update estimated MAC

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

protocol parameters in real time. The SuperMAC program will jointly optimize the interaction between the MAC and low-level network algorithms based on “right-case” assumptions derived from observed parameter data.

- (U) Program Plans:
- Demonstrate SuperMAC protocol performance impact through simulation of a large-scale tactical wireless ad hoc network.
  - Develop a hardware/software wireless test bed to validate simulation results.
  - Implement SuperMAC algorithms on military-grade software radio platforms for demonstration in a large-scale field test.

	FY 2006	FY 2007	FY 2008	FY 2009
Network Enabled Content Pushing	0.000	0.000	2.500	5.000

(U) The Network Enabled Content Pushing program seeks to reduce the time commanders wait for network downloads by learning and predicting what files and information they need. This program will also reduce peak network loads by timing downloads to occur at low network use periods. This program will use developed protocols and equipment to know the network’s condition at any time and only transfer files when network traffic is low. In addition, this program will allow the network to provide files before the users need them, shortening their wait for data. It will also allow users with periodic access to attach to the network and receive all the files the system expects them to need based on past activities, reducing the network’s communications load.

- (U) Program Plans:
- Develop a scalable architecture for efficiently publishing metadata on a world-wide distributed content network.
  - Develop network and routing discovery software that pinpoints routing and communications’ bottlenecks.
  - Develop software to: 1) learn what types of files and information users typically access; 2) convert this knowledge to metadata; and 3) publish the metadata to other content nodes.
  - Develop efficient algorithms to encode information to minimize network loading.
  - Develop methods to push and distribute required data to other locations in the content network with a minimum of network loading.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-03	

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Information and Communications Technology PE 0602303E, Project IT-04				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Language Translation IT-04	54.625	78.857	71.423	73.214	73.093	73.093	73.093	73.093

**(U) Mission Description:**

(U) This project is developing powerful new technologies for processing foreign languages that will provide critical capabilities for a wide range of military and national security needs, both tactical and strategic. The technologies and systems developed in this project will enable our military to automatically translate and exploit large volumes of speech and text in multiple languages obtained through a variety of means.

(U) Current U.S. military operations involve close contact with a wide range of cultures and peoples. The warfighter on the ground needs hand-held, speech-to-speech translation systems that enable communication with the local population during tactical missions. Thus tactical applications imply the need for two-way (foreign-language-to-English and English-to-foreign-language) translation.

(U) Because foreign-language news broadcasts, web-posted content, and captured foreign-language hard-copy documents can provide insights regarding local and regional events, attitudes and activities, language translation systems also contribute to the development of good strategic intelligence. Such applications require one-way (foreign-language-to-English) translation. Exploitation of the resulting translated content requires the capability to automatically collate, filter, synthesize, distill, and present relevant information in timely and relevant forms.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Situation Presentation and Interaction	11.739	18.757	14.188	12.533

(U) The Situation Presentation and Interaction efforts support the Spoken Language Communication and Translation System for Tactical Use (TRANSTAC) program. TRANSTAC will develop technologies that enable robust spontaneous two-way tactical speech communications between our warfighters and native speakers. The program addresses the issues surrounding the rapid deployment of new languages, especially, low-resource languages and dialects. TRANSTAC will build on existing speech translation platforms to create a rapidly deployable language tool

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-04	

that will meet the military’s language translation needs. For example, the program will add a two-way translation capability and will include Arabic dialects spoken in Iraq (the current Phraselator uses only Modern Standard Arabic).

(U) Program plans:

- Performed mission needs analysis and aggressive initial language data collection.
- Developed two-way translation systems (English and Iraqi Arabic) based on recent military tactical language needs.
- Developed and evaluated a two-way spoken English-Iraqi Arabic communication device for Stability and Support Operations.
- Develop new two-way translation software technologies for insertion into, and enhancement of, the two-way Iraqi systems.
- Develop and evaluate two-way translation technologies for Farsi.
- Develop tools for rapid deployment of new languages and dialects.
- Develop two-way translation systems in other languages (other than Iraqi Arabic) to enable the user to not only translate words but to communicate and carry on limited conversation.

	FY 2006	FY 2007	FY 2008	FY 2009
Automated Speech and Text Exploitation in Multiple Languages	42.886	60.100	57.235	60.681

(U) The Automated Speech and Text Exploitation effort is currently focused on two programs. The Global Autonomous Language Exploitation (GALE) program will develop and integrate technology to enable automated transcription and translation of foreign speech and text along with content distillation. The Multilingual Automatic Document Classification, Analysis and Translation (MADCAT) program will develop and integrate technology to enable exploitation of captured, foreign language, hard-copy documents.

- At present the exploitation of foreign language speech and text is slow and labor intensive. GALE will provide, in an integrated product, automated transcription and translation of foreign speech and text along with content distillation. When applied to foreign language broadcast media and web-posted content, GALE will enhance open-source intelligence and local/regional situational awareness and eliminate the need for translation and subject matter experts at every military site where such information is obtained. Thus, GALE will also reduce the military manpower requirements for translators and mitigate the escalating need for trained support personnel. GALE will

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-04	

tightly integrate multidisciplinary research and produce prototype systems. Earlier DARPA work in foreign language processing yielded an initial integrated architecture concept for speech transcription, text translation and information distillation resulting in near edit-worthy text. Continuing work under GALE will produce a fully mature integrated architecture and dramatically improve transcription and translation accuracy by exploiting context and other clues. GALE will address unstructured speech such as talk show conversations and chat room communications, and develop timely, succinct reports and alerts for commanders and warfighters.

- Hard-copy documents, including notebooks, letters, ledgers, annotated maps, newspapers, newsletters, leaflets, pictures of graffiti, and document images (e.g., PDF files, JPEG files, scanned TIFF images, etc.) resident on magnetic and optical media captured in the field, may contain important but perishable information of great potential value to the warfighter. These documents often contain machine printed and handwritten text in various combinations and orientations in one or more languages. Unfortunately, due to limited human resources and the immature state of applicable technology, our military does not currently have the ability to exploit, in a timely fashion, ideographic and script documents that are either machine printed or handwritten in Arabic or Chinese. MADCAT will address this need by producing devices that would enable soldiers to convert such captured documents to readable English in the field. MADCAT will substantially improve the applicable technologies, in particular document analysis and OCR/OHR (optical character recognition/optical handwriting recognition), tightly integrate these with translation technology, and create technology demonstration prototypes for field trials.

(U) Program Plans:

- Global Autonomous Language Exploitation
  - Designed and documented a GALE architecture based on the industry standard Unstructured Information Management Architecture (UIMA).
  - Created architectural components that combine the output of multiple machine translation engines.
  - Identified workflows of all processing engines and provided integration of these workflows on top of the architectural foundation.
  - Developed an integrated approach where the problem is viewed mathematically as a single system, with foreign speech/text as input, and English text and distilled information as output.
  - Evaluated GALE translation engines on the Arabic and Chinese languages for structured and unstructured speech and text.
  - Improved translation capabilities, reducing the translation errors by a factor of 2 in the first year.
  - Evaluated distillation technologies, reaching the first year targets by exceeding 50% of human performance.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-04	

- Developed a plan for a utility study to evaluate the effectiveness of the end-to-end system relative to a baseline search engine, and performed a preliminary study of the evaluation methods.
- Develop methods to optimize the parameters of speech-to-text acoustic models such that transcription errors are minimized on the training data.
- Develop discriminative training algorithms to optimize word alignment and translation quality.
- Develop methods for porting technology into new languages.
- Implement an integrated search of speech-to-text transcription and machine translation.
- Perform design and feasibility experiments for extraction-empowered machine translation, where the system extracts the meaningful phrases (e.g., names and descriptions) from foreign language text for highly accurate translation into English.
- Integrate metadata extraction into the speech-to-text components.
- Develop the architecture for a distillation system that incorporates adaptive filtering, focused summarization, information extraction, contradiction detection, and user modeling.
- Evaluate translation and distillation technologies and meet the high quality goals set by the program.
- Transition technologies developed by the GALE program into high-impact military systems and intelligence operations centers.
  
- Multilingual Automatic Document Classification, Analysis and Translation
  - Implemented new methods for Optical Character Recognition using 2-D linear transform techniques and graph theory matching techniques.
  - Improved methods for document segmentation (e.g., title, address box, columns, lists, embedded picture/diagram/caption, annotation, signature block, etc.).
  - Improve script (e.g., Roman vs. Cyrillic) and language (e.g., Farsi vs. Arabic) identification.
  - Develop algorithms for document type identification (e.g., letter, ledger, annotated map, newspaper, etc.).
  - Develop means to discriminate and separate handwriting from printed regions and improve OCR/OHR (optical character recognition/optical handwriting recognition) technologies.
  - Develop the means to interpret different regions within a document, for example, to extract the particulars from an address field or the axes of a table.
  - Develop algorithms to predict the syntactic structure and propositional content of text.
  - Develop tightly integrated technology prototypes that convert captured documents into readable and searchable English.

**UNCLASSIFIED**

R-1 Line Item No. 11

Page 24 of 26

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Information and Communications Technology PE 0602303E, Project IT-04	

- Integrate with the translation and distillation components of GALE.
- Enable efficient metadata-based search and retrieval.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 11

Page 26 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research				<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	159.244	180.003	179.728	202.439	220.494	219.243	224.243	236.038
Cognitive Systems Computing Foundations COG-01	12.878	22.053	4.474	0.000	0.000	0.000	0.000	0.000
Cognitive Computing COG-02	88.160	87.763	100.035	122.634	130.992	131.741	131.741	138.536
Collective Cognitive Systems and Interfaces COG-03	58.206	70.187	75.219	79.805	89.502	87.502	92.502	97.502

**(U) Mission Description:**

(U) The Cognitive Computing Systems program element is budgeted in the Applied Research budget activity because it is developing the next revolution in computing and information processing. The technology will allow computational systems to have reasoning and learning capabilities and levels of autonomy far beyond those of today’s systems. With the ability to reason, learn and adapt, and with facilities for self-awareness, these systems will know what they are doing, enabling new levels of capability and powerful new applications.

(U) Military operations since the end of the Cold War illustrate that current theater-level command, control, communications, and intelligence/information systems lack the ability to fully support operations in complex, time-critical environments. Warfighters must be prepared for operations ranging from conflict and peacekeeping in urban centers to heavy battle actions in remote areas. Current capabilities do not provide the commander with real-time, secure, situational awareness or the ability to orchestrate high-tempo planning, rehearsal, and execution. The programs in this project are developing and testing innovative, secure architectures and tools to enhance information processing, dissemination, and presentation capabilities. The programs provide the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making, and execution support capability, as well as secure multimedia information interfaces and software assurance to the warfighter “on the move.” Integration of collection management, planning, and battlefield awareness are essential elements for achieving battlefield dominance through assured information systems.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E	

(U) The Cognitive Computing project will develop core technologies that enable computing systems to learn, reason and apply knowledge gained through experience, and respond intelligently to things that have not been previously encountered. These technologies will lead to systems demonstrating increased self-reliance, self-adaptive reconfiguration, intelligent negotiation, cooperative behavior and survivability with reduced human intervention.

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

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	163.430	220.085	227.604	235.032
Current Budget	159.244	180.003	179.728	202.439
Total Adjustments	-4.186	-40.082	-47.876	-32.593
Congressional program reductions	0.000	-41.182		
Congressional increases	0.000	1.100		
Reprogrammings	0.000			
SBIR/STTR transfer	-4.186			

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E	

(U) **Change Summary Explanation:**

FY 2006                    The decrease reflects SBIR/STTR transfer.

FY 2007                    The decrease reflects congressional program reductions and a reduction for Section 8106 Economic Assumptions offset by a congressional add for the Secure Open Systems Institute for Defense.

FY 2008/09                The decrease reflects program rephasings following congressional reductions, the transfer of maturing cognitive technologies to BA3 for transition opportunities into command and control systems, and the realignment and continuation of the self-regenerative systems work from Project COG-01 to PE 0602303E, Project IT-03 to more clearly categorize DARPA information assurance activities.

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 12

Page 4 of 28

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Cognitive Computing Systems PE 0602304E, Project COG-01				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Cognitive Systems Computing Foundations COG-01	12.878	22.053	4.474	0.000	0.000	0.000	0.000	0.000

**(U) Mission Description:**

(U) Cognitive systems are different from conventional computing systems in that they draw inferences from rich structured representations of knowledge, learn from experience, combine symbolic logical knowledge with uncertain and probabilistic information, allow reflective reasoning, and support the integration of perceptual (e.g., visual, auditory) data with symbolic information. The next generation of computer systems will rely upon reasoning, learning, and self-monitoring to handle increasingly complex tasks. These systems will be advisable, adaptable and able to cope with surprise. As a result, these novel forms of computation will revolutionize future military systems. The Cognitive Systems Foundations project will develop the necessary foundational hardware architectures and software methods to facilitate learning and inference capabilities that are crucial to intelligent computing. These new computing foundations will help us move far beyond today's standard Von Neumann computing model.

(U) Cognitive systems for military applications must be robust and resistant to both attacks and system failures. The military faces aggressive and agile threats that have sufficient technical resources to mount sophisticated attacks using easily accessible commercial information systems. The pervasive nature of both the threat and its means drives the need for systems to dynamically adapt, collect and assimilate large quantities of systems operation data, and remain robust even under aggressive attacks or failure conditions. Cognitive Systems Foundations will enable future computer systems to be more responsible for their own configuration, monitoring, protection and restoration to full functional and performance capabilities after an attack or failure.

(U) Overall, this project seeks to make fundamental scientific improvements in our understanding of, and ability to, create more intelligent information and computing systems. Transition goals include next-generation network-centric systems and platform-specific information collection and processing systems in space, air, sea and land.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-01	

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Architectures for Cognitive Information Processing	6.428	10.790	0.000	0.000

(U) The Architectures for Cognitive Information Processing (ACIP) program is developing a new class of processing approaches, algorithms and architectures to efficiently enable and implement cognitive information processing, including the micro-architecture concepts, framework, and development environments. Current intelligent processing implementations depend on the use of existing numerically-based architectures and/or standard software architectures, and are therefore built on algorithms and processing foundations that are potentially ill-suited to cognitive tasks. Architectures that more directly mirror the symbolic reasoning, learning, and perception functions of a cognitive system are needed to enable major advances in this area. The ACIP program will establish core-processing capabilities that significantly advance the state of the art at all implementation processing levels – modules, systems, and underlying cognitive processing approaches, algorithms and architectures. In order to focus and establish context for the ACIP program, ACIP will pursue in-context DoD focused mission areas for the development of new data processing concepts. ACIP will develop implementations that span the areas of perception, reasoning and representation, learning, communication and interaction. The ACIP program will enable new classes of cognitive information processing applications that move the U.S. dramatically toward the overall goal of creating computer systems that know what they are doing.

**(U) Program Plans:**

- Developed initial cognitively-based processing techniques and architectural approaches in Phase I and demonstrated, with initial simulations, over two orders of magnitude improvement in performance.
- Evaluated initial common benchmarks, mini-applications, and metrics for the evaluation and comparative development of cognitive architectures.
- Develop multi-level programming models to support goal based and resource constrained cognitive application development.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Self-Regenerative Systems	6.450	10.163	4.474	0.000

(U) The Self-Regenerative Systems (SRS) program will design, develop, demonstrate and validate architectures, tools, and techniques for fielding systems capable of adapting to novel threats, unanticipated workloads and evolving system configurations. The technology developed under this program will employ innovative techniques like biologically-inspired diversity, cognitive immunity and healing, granular and scalable redundancy, and higher-level functions such as reasoning, reflection and learning. These technologies will make critical future information systems more robust, survivable and trustworthy. The SRS program will also develop technologies to mitigate the insider threat. The program will combine the SRS technology foundations in an exemplar military system that learns, regenerates itself, and automatically improves its ability to deliver critical services over time.

(U) SRS-enabled systems will be able to reconstitute their full functional and performance capabilities after experiencing an accidental component failure, software error, or even an intentional cyber-attack. SRS systems will show a positive trend in reliability, actually exceeding initial operating capability and approaching a theoretical optimal performance level over long time intervals. They will also maintain robustness and trustworthiness attributes even with growth and evolution in functionality and performance. The program will explore a self-regenerative operating system that will automatically recover after failure or attack on its configuration files, underlying devices or applications; and provide core survivability functionality, programming interfaces and system services that support rapid prototyping, construction, and deployment of survivable applications. In FY 2008, the follow-on phase of the Self-Regenerative Systems program will transition to PE 0602303E, Project IT-03, the host project for all of DARPA's information assurance and survivability programs.

(U) Program Plans:

- Developed technologies to diagnose and assess damage, repair and recover from damage caused by accidental faults, software aging or malicious activities.
- Developed general strategies to preempt insider attacks, enabling anomaly detection, combining and correlating information from system layers, and using direct user challenges.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-01	

- Tailor an exemplar self-regenerative system representative of a military application, thereby demonstrating the protective value to the warfighter.

	FY 2006	FY 2007	FY 2008	FY 2009
Secure Open Systems Institute for Defense (SOSI)	0.000	1.100	0.000	0.000

- (U) Program Plans:
  - Initiate research on Secure Open Systems.
- (U) **Other Program Funding Summary Cost:**
  - Not Applicable.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Cognitive Computing Systems PE 0602304E, Project COG-02				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Cognitive Computing COG-02	88.160	87.763	100.035	122.634	130.992	131.741	131.741	138.536

**(U) Mission Description:**

(U) In the real-time environment of military operations, cognitive networks and systems that can learn, reason, draw on their experience, automatically adapt to maintain critical functionality, effectively assist their military user and improve their responses over time will be crucial to operational success. These capabilities will make the difference between mission success and mission degradation or failure, even in the event of cyber-attack or component attrition resulting from kinetic warfare or accidental faults and errors. Systems that learn and reason will reduce the requirement for skilled system administrators and dramatically reduce the overall cost of system maintenance. As the military moves towards a dynamic expeditionary force, it is critical for systems to become more self sufficient.

(U) The Cognitive Computing project will develop core technologies that enable computing systems to learn, reason and apply knowledge gained through experience, and to respond intelligently to new and unforeseen events. These technologies will lead to systems with increased self reliance, cooperative behavior, the capacity to reconfigure themselves, and survivability with reduced programmer intervention. In cognitive architectures, there are three primary types of processes: reactive, deliberative and reflective. Reactive processes respond quickly and directly to known stimuli; deliberative processes embody what is usually known as “thinking;” and reflective (higher-order) processes allow a system to “step back” and evaluate the environment and its own capabilities to decide the next appropriate course of action. Each of these processes will be improved through learning. Individual technical capabilities developed in this project include novel representations for knowledge, skill learning, algorithms for automated reasoning (deductive, abductive, planning, strategic inference, and hybrid approaches), pattern detection capabilities, and language learning. Overall, the project will extend fundamental computing capabilities to deal with real-world information complexity and uncertainty.

(U) The machine learning, reasoning, and human-machine dialogue techniques developed in this project, in particular, in the Integrated Cognitive Systems program, have great applicability to command and control systems and are budgeted to begin transition to battlefield systems in FY 2008. Candidate systems include the Army’s Command Post of the Future (CPOF), the Navy’s Composeable FORCENet and the Air Force’s Air Tasking Order Programs. Details are provided under PE 0603760E, Project CCC-01.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-02	

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Integrated Cognitive Systems	49.454	32.982	36.231	40.576

(U) The Integrated Cognitive Systems technology thrust seeks to enable intelligence in information processing systems so that critical DoD systems can better support, not burden, the warfighter. Due to DoD/military reductions in manpower levels, and in spite of the integration of advanced information technologies and automation throughout defense systems, the workload on the war fighter steadily increases. Modern computing systems, though powerful, are woefully lacking in the capability to self-configure, adapt, and learn, i.e., they lack even rudimentary intelligence. This deficiency places a heavy burden on the warfighter to operate and maintain the very information technology on which modern warfare depends. The Integrated Cognitive Systems thrust will develop advanced technology to enable a new class of cognitive systems capable of assisting military commanders and decision makers. This thrust will build upon prior DARPA programs that developed improved human-computer interaction capabilities and highly-responsive computing systems. Integrated cognitive systems will be able to plan ahead and understand the world well enough to plausibly anticipate future events. Most importantly, these systems will have embedded learning capabilities that will allow them to retain prior learned knowledge, apply this knowledge to new scenarios and ultimately provide faster and more effective assistance. Overall, the ability to learn will enable the performance of a cognitive system to improve over time. The Integrated Cognitive Systems technologies will be developed in the Personalized Assistant that Learns (PAL) program. Cognitive Systems technologies developed in this program will be applied and demonstrated in the Increased Command and Control Effectiveness (ICE) program (PE 0603760E, Project CCC-01) prior to transition into Command Operations.

- The PAL program is creating a revolutionary technology for commanders and warfighters - the first comprehensive system that will dramatically empower commanders to understand at a glance all aspects of the current military situation, radically reduce manpower and labor required in command posts and in the field, and automate the massive number of administrative and analytical tasks characteristic of today's command centers. The PAL program is creating a new generation of machine learning technology that will enable information systems to automatically adjust to new environments and new users, helping commanders adapt to new enemy tactics, evolving situations and priorities, accelerating the incorporation of new personnel into command operations, and making more effective, focused use of resources. Applications developed in PAL will be adapted and hardened in order to be integrated into existing military systems.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-02	

Ultimately, future capabilities to be inserted will enable: turning diverse, multi-source data into actionable information for commanders and warfighters; dramatic manpower reductions; corporate memory retention of both the larger conflict history and the history of each specific command center; and intelligent information presentation.

(U) Program Plans:

- Personalized Assistant that Learns
  - Developed, evaluated, and demonstrated the first instance of an intelligent cognitive assistant.
  - Developed, demonstrated, and refined core machine learning, knowledge base and flexible planning technologies to enable development of a cognitive planning agent.
  - Develop, demonstrate, and evaluate core physical awareness, cyber-awareness, multimodal dialogue, machine learning, and representation and reasoning technologies to support cognitive assistant executive functions.
  - Develop the ability for an integrated cognitive system to examine its own behavior and learn from that experience.
  - Develop a dialogue system with general and domain-specific semantics for eliciting natural language advice from the warfighter and other end users. This dialogue system will translate user guidance into the precise machine language necessary for both implementation and verification of purpose and intent.
  - Demonstrate PAL technology applied to warfighting problems, integrate with warfighting information systems, test during military exercises and validate that PAL technologies are robust to the dynamics and uncertainties associated with the battlefield.
  - Integrate PAL technology into military Command and Control (C2) systems such as the Command Post of the Future.

	FY 2006	FY 2007	FY 2008	FY 2009
Foundational Learning Technology	22.315	33.057	36.614	46.549

(U) The Foundational Learning Technology thrust seeks to develop advanced machine learning techniques that enable cognitive systems to continuously learn, adapt and respond to new situations by drawing inferences from past experience. The technologies developed in this thrust area have broad applicability to cognitive systems, and will result in military systems that are more robust, self-sufficient, and require minimal or no platform-specific customization. Current projects will develop hybrid learning techniques to create cognitive systems capable of learning

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-02	

military strategy, leveraging large amounts of prior knowledge, incorporating external guidance and applying prior knowledge in real-time to the naturally changing environment, all without programmer intervention. The Foundational Learning Technology thrust includes three programs: Real-World Learning, Integrated Learning, and Bio-Inspired Cognition.

- The Real-World Learning program will explore the integration and application of advanced machine learning techniques to further enable cognitive computing systems to learn from experience and adapt to changing situations. The program will emphasize Transfer Learning Techniques providing the ability to transfer knowledge and skills learned for specific situations to novel, unanticipated situations and perform appropriately and effectively the first time a novel situation is encountered. This is essential because most military operations occur in ever-changing environments, and U.S. forces and systems must be able to act appropriately and effectively the first time each novel situation is encountered. The program will drive the design and implementation of new hybrid learning technologies, such as large-scale transfer learning, multi-purpose extensible knowledge learning, learning with minimal direction, learning adaptable and efficient network structures, strategy learning, learning from text, learning intent of information, and learning generalized task models. The program will stress technologies that combine statistical learning techniques with knowledge techniques that take into account background knowledge and *a priori* experience. The resulting technologies will a) learn and represent vast amounts of knowledge in forms that can be applied to unknown situations and domains; b) generalize learned knowledge and apply it to dynamic and unpredictable situations; and c) reason about a situation or environment.
- The Integrated Learning program will create a new computer learning paradigm in which systems learn complex workflows from warfighters while the warfighters perform their regular duties. Current machine learning technologies cannot learn these complex workflows. The program is focused on military planning tasks such as air operations center (AOC) planning and military medical logistics. With this learning technology, it will be possible to create many different types of military decision support systems that learn by watching experts rather than relying on hand-encoded knowledge (which is expensive and error prone to produce). The new learning paradigm differs from conventional machine learning in that it does not rely on large amounts of carefully crafted training data. Rather, in the new paradigm the learner works to “figure things out” by combining many different types of learning, reasoning, and knowledge. For instance to learn AOC tasks, the computer learner combines what it observed the warfighters doing with the knowledge it has about aircraft, and reasons about airspace de-confliction to create a generalized model that can then be used to perform the entire AOC task, or provide intelligent instruction to other warfighters performing the same task.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Cognitive Computing Systems PE 0602304E, Project COG-02	

- The Bio-Inspired Cognition program has taken a fresh look at the design and implementation of bio-inspired cognitive architectures modeled after human cognition that combine principles from neuroscience and cognitive psychology with traditional artificial intelligence-based symbol processing and knowledge representation. The program draws on continuing advances in neurophysiology and cognitive psychology to guide and augment traditional artificial intelligence (AI) approaches to learning, reasoning, memory, knowledge acquisition and organization, and executive functions. The work has focused on new capabilities in memory, categorization, pattern recognition and fusion of perceptual/sensory information to emulate human performance by exploiting past experience in novel situations, learning in multiple ways, fusing multiple perceptual inputs in real-time, extracting concepts from specific experiences, forming hierarchies of associated memories and concepts, and directing attention through a complex executive process. Success is being measured by the ability of the systems developed to deal effectively with novel situations and respond appropriately in reasonable timeframes.

(U) Program Plans:

- Real-World Learning
  - Established several test beds of complex multi-agent environments for the generation of specific and novel situations that will be used to evaluate learning techniques and components.
  - Demonstrated the ability of a cognitive agent to learn large amounts of knowledge for performance in a specified domain on an unknown task within the same domain.
  - Explored novel methods for acquiring new knowledge including direct input through processing natural language text.
  - Design and develop hybrid learning systems that allow cognitive systems to generalize based on information gathered and learn to operate successfully in similar, but not identical situations, adapt to a wide variety of naturally-occurring situations, and perform better over time.
  - Demonstrate the ability of a cognitive agent to combine and restructure knowledge from multiple domains to solve novel problems. This includes the ability to generalize knowledge from a particular domain, recognize its applicability and apply it to a problem in a new domain. It also includes the ability to apply knowledge effectively, apply skills acquired for one purpose to other purposes, and demonstrate the ability to propose novel problem solution methods when specified resources are unavailable.
  - Demonstrate the ability of learning techniques to improve representation and reasoning performance in complex multi-agent environments.
  - Develop the ability of a cognitive agent to solve a problem with incomplete/partially inaccurate directions and achieve a goal that is only implicit in a specified task set of directions.

UNCLASSIFIED

R-1 Line Item No. 12

Page 13 of 28

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-02	

- Develop software tools that learn to adapt and optimally configure organizational structures, such as military commands, for robust complex decision making (e.g., logistics) and information sharing.
- Develop software that integrates learning from examples, heuristic reasoning and textual analysis to recognize intent (i.e., cooperative or adversarial) behind human communications, and other information.
- Develop the ability to learn information directly from large volumes of text using existing knowledge to guide the learning.
  
- Integrated Learning
  - Formulate learning as integrated problem solving. Develop techniques for representing and reasoning about explicit learning goals, formulating plans to achieve these goals, creating hypothesis where appropriate, and resolving sources of uncertainty.
  - Combine different types of knowledge and reasoning, flexibly. Enable learners to assemble information from many different sources including general-purpose world knowledge, more specific domain knowledge, reasoning, and simulation.
  - Develop a new set of learning algorithms that focus on learning structures or models rather than refining parameter values.
  - Develop learning algorithms that explicitly design experiments to test hypothesis about learned knowledge.
  - Develop knowledge sharing data structures that enable different learner subcomponents to share knowledge directly.
  - Test learning techniques by learning air operations center (AOC) and military medical logistics planning processes.
  
- Bio-Inspired Cognition
  - Investigated algorithms and general principles inspired by neuroscience to create new hybrid learning and adaptive systems.
  - Developed a set of cognitive architectures that modeled the major psychological and neurobiological aspects of human cognition.
  - Developed a battery of tests for evaluating cognitive architectures: a “cognitive decathlon” for assessing specific skills associated with cognition (e.g., visual perception, memory).”

	FY 2006	FY 2007	FY 2008	FY 2009
Learning Locomotion and Navigation	11.851	15.311	19.171	22.000

(U) The Learning Locomotion and Navigation thrust will develop advanced robotic technologies that will enable autonomous (unmanned) mobile platforms to perceive, understand, and model their environment; navigate through complex, irregular, and hazardous terrain; make

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Cognitive Computing Systems PE 0602304E, Project COG-02	

intelligent decisions corresponding to previously programmed goals; and interact cooperatively with other autonomous and manned vehicles. These capabilities will enable robotic vehicles to support warfighters in a variety of situations and terrains, including transportation, logistics, reconnaissance, and active battle. A key objective is robust navigation and locomotion, since this underlies the ability to move through the difficult and unpredictable terrain of theater operations, which may include highly irregular and mountainous areas, partially-destroyed roads, rubble-filled urban terrain, and other vehicles and personnel. This program also supports the DARPA Urban Challenge.

(U) Within the thrust area, efforts are being made to develop learning and reasoning technologies to address specific concerns in both wheeled and legged robotic systems. Current systems for autonomous ground robot navigation typically rely on hand-crafted, hand-tuned algorithms. While these systems may work well in open terrain or on roads with no traffic, performance falls far short in obstacle-rich and highly-irregular environments. In contrast, the approach taken here is to develop systems that automatically learn to interpret sensor data and apply this knowledge to actuator control to improve locomotion and navigation in complex environments. Learning techniques will include (but not be limited to) reinforcement learning and learning from examples. These advancements will open new horizons for unmanned military operations, surveillance and reconnaissance, and dramatically advance the capabilities of autonomous vehicles. Tasks requiring higher-level computation, such as perception-based navigation and a high degree of freedom articulation will greatly benefit as well.

(U) Although current approaches to autonomous navigation of unmanned vehicles have achieved notable success in recent years, they suffer from limitations due to having been developed for static environments and not for dynamic real-world environments. Examples of the challenges posed by a complex dynamic real-world environment include: (1) robotic vision outdoors, under windy conditions that result in the movement of vegetation, trees, and leaves and, when a body of water is present, waves; and (2) path-planning in the presence of moving "obstacles" such as people and other (manned or unmanned) vehicles. Improvements in robotic vision and scene understanding, including the capability to predict the future location and even the intent of moving objects, need to be integrated with more sophisticated approaches to path planning. This would set the stage for autonomous interacting robots that share information and collaborate in performing tasks. For example, interacting robots could collaborate in planning/traversing a diversity of routes and thereby enhance their likelihood of quickly finding a viable and/or (nearly) optimal path.

UNCLASSIFIED

R-1 Line Item No. 12

Page 15 of 28

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-02	

(U) Program Plans:

- Learning Locomotion and Navigation
  - Explored various learning technologies that enabled rapid adaptation by robots to new physical environments and improved autonomous vehicle speed over rough terrain.
  - Developed several learning methods that allowed learned navigation algorithms to surpass the performance of a baseline system which was demonstrated through several experiments.
  - Explored “learning from example” and “reinforcement learning” applications to develop technology for autonomous vehicle systems to learn and gather experience without relying on a programmer to anticipate all eventualities. These learning approaches were evaluated through a series of tests in varying terrains.
  - Continue to explore the integration of various learning technologies to enable rapid adaptation by robots to new physical environments and improve autonomous vehicle speed over rough terrain.
  - Develop learning methods that allow their learned navigation algorithms to surpass the performance of a baseline system.
  - Transfer the best performing navigation methods learned on a small-scale vehicle to the large robotic vehicle, Crusher, to operate at increased speeds in complex environments.
  - Port learning locomotion algorithms to larger scale vehicles to increase mobility of larger scale robots.
  - Create learning locomotion toolkits that will control a diverse set of high degree-of-freedom vehicles on rough terrain.
  - Fund prizes, technology development contracts, and program planning support for the DARPA Urban Challenge.

	FY 2006	FY 2007	FY 2008	FY 2009
Knowledge Representation and Reasoning Technology	4.540	6.413	8.019	13.509

(U) This program will develop the technologies to achieve the next generation of intelligent, knowledge-intensive systems and is comprised of two thrusts; 1) Knowledge Representation and Reasoning Technology and 2) Bootstrapped Learning.

- The Knowledge Representation and Reasoning Technology thrust (formerly Knowledge-Based and Reasoning Technology) will develop enabling technologies to acquire, integrate, and use high performance reasoning strategies in knowledge-rich domains. Such technologies will provide DoD decision makers with rapid, relevant knowledge from a broad spectrum of sources that may be dynamic and/or

**UNCLASSIFIED**

R-1 Line Item No. 12

Page 16 of 28

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Cognitive Computing Systems PE 0602304E, Project COG-02	

inconsistent. Significant reasoning challenges arise from the fact that critical knowledge involves context, temporal information, complex belief structures, and uncertainty. To address these challenges new capabilities are needed to extract key information and metadata, and to exploit these via context-capable search and inference (both deductive and inductive). DoD systems sense, capture, and store information in the form of text, audio, imagery, and video. Therefore, advanced machine reasoning capabilities must extract knowledge from and reason about all types of multimedia data. Visual-spatial reasoning, which is perhaps the most powerful form of human reasoning, yet the one least covered by machine cognition, is of special interest. This research will explore new computational models to enable command and control systems to use conceptual representations to perform visual-spatial reasoning and to assist the commander in understanding and analyzing complex battlefield scenarios.

(U) People are able to learn complex concepts, but they require a customized curriculum designed to teach a hierarchy of concepts at different levels of representation where each level depends on having learned the previous level. Bootstrapped Learning (BL) will provide computers with the same capability, enabling rapid learning of complex high-level concepts. At each level, a rich set of knowledge sources (such as training manuals, examples, expert behaviors, simulators, and references and specifications that are typically used by people learning to perform complex tasks) will be combined and used to generate concepts and a similar set of knowledge sources for the next level. Key to this process is the ability to automatically re-represent these combined sources into a common representation as needed for learning and reasoning. The ability to perform BL is essential for autonomous military systems because they will need to understand not only what to do but why they are doing it, and when what they are doing may no longer be appropriate. To be useful, a military system must not only carry out the specific task/mission for which it is programmed but also be able to reflect on its own ability to do so, and do this in the context of its operator/controller's intent.

(U) Program Plans:

- Knowledge Representation and Reasoning Technology
  - Developed and implemented initial digital repository architecture.
  - Develop integrated knowledge representation and learning technology that enables effective representation of essential forms of knowledge.
  - Develop representations of events and methods for separating and tracking their association to merge multiple scenarios, assimilate one event within the context of the other, and identify where events deviate from the norm.
  - Develop a general inference engine based on spatial representations, transformations, and reasoning techniques, in order to provide a more intuitive, common sense, human-like and efficient visual reasoner.

UNCLASSIFIED

R-1 Line Item No. 12

Page 17 of 28

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Cognitive Computing Systems PE 0602304E, Project COG-02	

- Create learning mechanisms for the discovery of novel object categories and then design, develop, and demonstrate an artificial system that is capable of context-sensitive visual scene interpretation and understanding.
- Bootstrapped Learning
  - Create a general purpose “Ladder Interface” used to decouple the bootstrap learning system from the problem domains and instructional materials provided to them.
  - Produce end-to-end systems capable of bootstrap learning, integrating different types of learning, input modalities, and repeatedly building on prior learning.
  - Demonstrate a single system capable of being instructed to perform in three diverse domains.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research				<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-03				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Collective Cognitive Systems and Interfaces COG-03	58.206	70.187	75.219	79.805	89.502	87.502	92.502	97.502

**(U) Mission Description:**

(U) Warfighting is not an individual activity. Battles, engagements, and even peace keeping missions are won by teams of warfighters working in concert with each other and the automated systems that support them. These warfighters are operating in hard settings where action, information, and decision making are distributed and the situation is constantly changing. In these settings, communications, information sharing, and tools that support warfighter coordination are critical.

(U) The Collective Cognitive Systems and Interfaces Project will dramatically improve warfighter and commander effectiveness and productivity using advanced cognitive approaches that enable faster, better informed, and more highly coordinated actions than those of our enemies. This will be accomplished by developing revolutionary methods that increase our information processing capabilities, enhance our situational awareness, and enable more cohesive group action by our forces. Critical technical areas addressed in this project include automated coordinated decision support, information sharing, and ensured communications. Cognitive decision support tools reason about tasks, timings, and interactions so that when plans change or the enemy does not respond as anticipated, U.S. forces can quickly adapt. The quality of such decisions and the effectiveness of our actions depend critically on our ability to take full advantage of all available information in a rapid and flexible manner. This requires the capability to share information and to automatically integrate distributed information bases for broad tactical battlespace awareness. Finally, team cohesion requires effective and reliable communication in difficult environments such as the urban setting where radio signal propagation is complex. Here the approach is to develop cognitive communications management and control algorithms that reason about channel conditions, higher-level application connectivity requirements and related factors, and decide (often as a group) what parameters (e.g., frequency) each radio will use. The suite of programs under this project will significantly advance the military's ability to address and deal with complex situations in operational environments.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Cognitive Computing Systems PE 0602304E, Project COG-03	

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Collaborative Cognition	21.304	29.951	32.800	34.002

(U) The Collaborative Cognition thrust is aimed at developing technologies that enable individual cognitive agents to work together as a team to provide cooperative support to warfighters in complex military situations. Such situations typically require multiple coordinated tasks that involve information sharing and cooperative efforts. The Collaborative Cognition thrust will foster the design and implementation of collaborative software agents that operate in dynamic environments that include both software agents and people. Applications include collaborative surveillance and reconnaissance, logistics re-planning and decision support for unanticipated operational changes, situational analysis, prediction tools, and warfighter/commander decision aids. The technology will also allow software agents to cope with limited and/or noisy sensor information, limited communication capabilities, changing and unforeseen environments, other agents, and limited *a priori* knowledge of each other's capabilities. The Collaborative Cognition technology thrust consists of two programs: Coordination Decision-Support Assistants (COORDINATORS), and Advanced Soldier Sensor Information System and Technology (ASSIST).

- The Coordination Decision-Support Assistants (COORDINATORS) program will develop cognitive software coordination managers that provide support to fielded tactical teams. The coordination managers will help fielded units adapt their mission plans in response to inevitable, unanticipated changes in the mission by tracking personnel, resources, situational changes, and proposing and evaluating options (adjustments to task timings, changes to task assignments and selection from pre-planned contingencies). This will enable fielded units to respond faster and more accurately to the dynamically changing battlefield situation, requiring far fewer personnel in the re-planning process. COORDINATORS is a distributed technology. A single COORDINATOR will be partnered with each tactical unit or team, and will be able to collaborate and coordinate with other tactical units to optimize needed mission changes.
- A key lesson learned from Operation Iraqi Freedom (OIF) is the importance of accurate observational reporting by ground soldiers. The Advanced Soldier Sensor Information System and Technology (ASSIST) program will develop an integrated information system that exploits soldier-worn sensors to augment the soldier's ability to capture, report, and share information in the field. Communication of

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-03	

timely and accurate information is vital for enhanced situational understanding and overall operational effectiveness in urban combat and post-conflict stability operations. While a range of standardized reporting mechanisms are in use today, the confusion of the battlefield/urban operations combined with physical and psychological stresses on the warfighters can make the task of reporting very difficult. Furthermore, existing verbal and text-format reports limit the soldier's ability to capture and convey the full picture, particularly annotated visual information. The ASSIST program will develop an integrated system using advanced technologies for processing, digitizing and analyzing information captured and collected by soldier-worn sensors. It will draw heavily on the experiences and lessons learned from previous OIF missions and other surveillance and reconnaissance missions. A baseline system will demonstrate the capture of video/still images together with voice annotations and location-stamping. The advanced system will demonstrate automatic identification and extraction of key objects, events, activities and scenes from soldier-collected data. The system will create knowledge representations that will serve as an input to an array of warfighter products including augmented maps, situational analysis tools, and query and answer capabilities.

(U) Program Plans:

- Coordination Decision-Support Assistants
  - Tested coordination algorithms in a lab setting on small-scale coordination problems (8 COORDINATORS, 64 mission tasks) and demonstrated that algorithms achieve nearly optimal results in seconds.
  - Develop distributed coordination technology that reasons about making changes to task timings, assignments, and selection from preplanned contingencies.
  - Develop a coordination autonomy technology that learns which response options are most highly valued so that the COORDINATORS generate an appropriate option when the warfighters are occupied or cannot be interrupted.
  - Develop a meta-cognition technology that reasons about resource allocation (i.e., where a given COORDINATOR should spend its processing time), so the entire system can engage in difficult processing tasks but still respond in real time.
  - Create algorithms that reason about military decision-making policies and procedures so COORDINATORS follow correct information exchange protocols and ensure that decisions and recommendations stay within the scope of authorization.
  - Develop a Commander's COORDINATOR that can selectively "drill down" into portions of the mission structure and collect up-to-the-minute information, enabling a commander to make adjustments or recommendations.

UNCLASSIFIED

R-1 Line Item No. 12

Page 21 of 28

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-03	

- Advanced Soldier Sensor Information System and Technology (ASSIST)
  - Demonstrated the baseline capture and retrieval system prototype and evaluated the effectiveness of the integrated system in MOU (Military Operations on Urban Terrain) field exercises.
  - Developed algorithms to identify objects, events, and activities in captured data and to assign correct labels.
  - Exploited multimodal sensor streams and contextual information.
  - Created a taxonomy of objects and events, collected test data, and developed procedures and metrics for advanced technology evaluation.
  - Developed a laptop-based user search and visualization interface for accessing logged information captured by multiple soldiers.
  - Demonstrated temporal event representation and outdoor spatial representation.
  - Demonstrate real-time reporting using on-soldier sensors and intuitive information push/pull user interface.
  - Develop key technological components that enable in-field data sharing and retrieval on a wearable computing/sensor platform.
  - Demonstrate eyes-free, hands-free, attention-free collection of key events and experiences for reporting.
  - Demonstrate tools for analyzing blue-force and red-force trends and patterns.
  - Demonstrate the system's ability to improve its event and object classification performance through learning; demonstrate an accelerated capability for recognizing new classes of events, objects and activities.
  - Integrate advanced multimodal sensor event and object extraction techniques into advanced systems and evaluate the enhanced capabilities.

	FY 2006	FY 2007	FY 2008	FY 2009
Cognitive Networking	22.616	28.536	30.986	31.873

(U) The Cognitive Networking research thrust will develop technologies that provide information systems and communication networks with the ability to maintain their own functionality, reliability and survivability. These technologies will allow the military to focus its critical manpower resources on the mission rather than on the maintenance of its information systems and network infrastructure. Research in this area will create a radical new design for distributed computers, device networks, and the software to manage these systems. It will also attempt to create a “cognitive radio” capability, which uses cognitive information processing to optimize communications based on current conditions, past

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-03	

experience and high-level user guidance. The Cognitive Networking thrust comprises three programs: Situation-Aware Protocols in Edge Network Technologies, Adaptive Cognition-Enhanced Radio Teams, and Brood of Spectrum Supremacy.

- The Situation-Aware Protocols in Edge Network Technologies (SAPIENT) program will develop a new generation of cognitive protocol architectures to replace conventional protocols that fare poorly in extreme network conditions and do not provide adequate service for key applications. Technology developed in the SAPIENT program will have military utility wherever tactical communications are deployed. SAPIENT architectures will represent awareness with a knowledge base that is updated based on specification and observation. This technology enables the automatic adaptation of protocols to the operational environment. SAPIENT will exploit attributes of human cognition, such as learning and self-improvement, and apply them to the automated construction of network protocols. Key research challenges for the SAPIENT program are the use of these cognitive attributes to dramatically reduce the effect of network impairments on applications while demonstrating a positive trend in this capability as new situations are encountered and learned. Desired capabilities include interoperable knowledge representations and rapid incorporation of new knowledge about applications, network conditions and building blocks from which new protocols can be constructed.
- The Adaptive Cognition-Enhanced Radio Teams (ACERT) program is enabling distributed radio teams that are able to use capabilities inherent in aggregating nodes thereby leveraging advantages that are unique to a distributed system. ACERT focuses on techniques to enhance basic radio capabilities by combining the information available to the individual radios and making it available to the team. Of particular interest is sharing individual measurements of the radio channel to derive a shared common map of the local propagation conditions. Such a radio frequency propagation mapping capability can serve as the basis for improved message routing resulting in more reliable communications for small unit operations in urban environments.
- The Brood of Spectrum Supremacy (BOSS) program will provide actionable situational awareness to the warfighter in complex radio frequency (RF) environments. BOSS adds collaborative processing capabilities to tactical software-defined radios to achieve specific military goals. BOSS exploits cooperative use of computational, communication and sensory capabilities in a software radio, in aggregate, to generate breakthrough capabilities in the warfighter knowledge of their surroundings, with a particular focus on RF-rich urban operations. The BOSS program will initially focus on modeling and simulation, resulting in hardware-independent executable specifications of waveforms in an interoperable format. Once the modeling and simulation is verified, the BOSS program will develop a prototype demonstration for a performer-selected RF platform, using and refining the hardware-independent executable specifications of

UNCLASSIFIED

R-1 Line Item No. 12

Page 23 of 28

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-03	

the waveforms. Ultimately this program will develop Software Communications Architecture (SCA)-compliant waveforms suitable for implementation on a tactical software radio system.

(U) Program Plans:

- Situation-Aware Protocols in Edge Network Technologies (SAPIENT)
  - Created knowledge representations appropriate for describing some situations encountered in tactical military networks (e.g., weak signals, propagation obstructions, message priorities and security requirements) and for enabling machine response to these situations.
  - Create and refine new knowledge representations appropriate for describing multiple link situations encountered in tactical military networks and for enabling machine response to these situations including automated learning of effective responses.
  - Demonstrate SAPIENT capabilities in laboratory and experimental airborne venues.
  - Integrate and enhance prototypes and evaluate their performance.
- Adaptive Cognition-Enhanced Radio Teams (ACERT)
  - Identified the technology challenges associated with the establishment of collaborative radio teams.
  - Created models, algorithms and prototypes for distributed control of radio resources and shared situational awareness.
  - Demonstrated the capability to share channel characteristics across multiple distributed radio units and produce a map of radio frequency propagation.
- Brood of Spectrum Supremacy (BOSS)
  - Develop theoretical analyses of the software-defined radio trade space to assess the distributed aggregation of capabilities over different numbers of moving elements, elements with varying capabilities (e.g., RF and processing), and with different distances and locations.
  - Refine capabilities of Software Communications Architecture (SCA)-compliant platforms, while working within the software-defined radio trade space.
  - Validate algorithms and implementations for network understanding tasks.

UNCLASSIFIED

R-1 Line Item No. 12

Page 24 of 28

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-03	

	FY 2006	FY 2007	FY 2008	FY 2009
Integrated Collective Systems	3.561	9.700	11.433	13.930

(U) The Integrated Collective Systems technology thrust (formerly Self-Sufficient Collective Systems) will enable warfighters to take full advantage of all available pertinent information in a rapid and flexible manner. It will create software technologies that enable future warfighters to share information and to automatically integrate distributed information bases for broad tactical battlespace awareness. Ultimately, the selection, generation, sharing, integration and display of information will be handled by cognitive software systems coupled with each warfighter, and as information is shared the network of individual systems will form a collective. Information integration is one of the most critical and challenging problems facing the DoD and continually tops the list of critical defense needs. The inability to share and integrate data and information results in a fragmented picture of the battlespace where only a fraction of the available information is actually used. For example, it has been reported that in many instances it was easier to re-task an asset to collect new information than it was to retrieve critical information from data already collected and analyzed. Integration of multimedia (text, video, digital photographs) is of particular interest as it may contain valuable intelligence “tidbits” with different degrees of subtlety that can be extremely time-consuming to manually analyze (this is the case today). Once analyzed, such data needs to be indexed and stored so it can be queried and retrieved. Automatic analysis, querying and correlation algorithms need to be developed to minimize manual intervention.

(U) Current practices in the area of digital storage and information management generally optimize file storage and retrieval for the individual but are poorly suited to the sharing of large volumes of digital information across workgroups and enterprises. The DARPA Network Archive (DNA) project is pursuing a network-based approach to information storage and management that will enable a network-based repository to hold all digital information. Because it resides on the network, the DNA repository will provide a mechanism for the virtual (i.e., logical, not physical) centralization of all enterprise information. DNA technology will enable and facilitate controlled access to information by approved and authenticated users across administrative domains, and in this fashion it will enable a collective view of enterprise information. Repositories built on DNA technology will, in addition, provide a single distributed platform/framework for additional document/content/information services including indexing, metadata creation, search, versioning, and records management, resulting in the warfighter’s ability to take full advantage of all available pertinent information in a rapid and flexible manner.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-03	

- (U) Program Plans:
- Develop a comprehensive digital repository architecture to enable ubiquitous access from multiple devices while providing secure, effective, document sharing.
  - Develop a prototype system with military applicability that could accommodate thousands of users and further facilitate an open, extensible, and vendor-independent architecture.
  - Develop a variety of innovative services for the architecture and prototype subsystems to address such issues as access control, security, indexing and search, metadata creation and maintenance, and version tracking.
  - Devise new approaches for reasoning about information, information fusion, and handling conflicting information from different sources to enable warfighter systems to concurrently operate in multiple information collectives/domains.
  - Develop multimedia database techniques to store the raw content and associated metadata associated in order that search, correlation, and analysis are enabled.
  - Develop data discovery techniques to automatically search multimedia databases, semi-structured collections of data, and unstructured text collections for correlations and actionable intelligence.
  - Develop advanced automatic techniques for analyzing and correlating a wide variety of multimedia data with an emphasis on specific algorithms that can derive key analytic features without solving the general scene analysis problem.
  - Create new multimedia analysis algorithms with an emphasis on using context to determine feature attributes.

	FY 2006	FY 2007	FY 2008	FY 2009
Improved Warfighter Information Processing (IWIP)	10.725	2.000	0.000	0.000

(U) The Improved Warfighter Information Processing (IWIP) technology thrust developed technologies to enhance the warfighter's and commander's information management capacities and improve decision-making performance. The main thrust of this program was the Improving Warfighter Information Intake under Stress program. The Improving Warfighter Information Intake under Stress program enhanced operational effectiveness through a set of cognitive techniques that specifically improve 1) the amount of information that warfighters can handle; 2) attention management during stressful operations; and 3) information retention (memory). The program developed the means, devices and infrastructure

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Cognitive Computing Systems PE 0602304E, Project COG-03	

necessary to assess the warfighter's or commander's cognitive status in real time, and used adaptive strategies specific to his/her status to improve information processing and decision-making. The IWIP program is in the process of transitioning to the Army, Navy, and Air Force.

- (U) Program Plans:
- Refined closed-loop computational interfaces to mitigate specific information-processing bottlenecks to improve performance and information flow in specific operational domains.
  - Refined intelligent interruption strategies, adaptive attention management methods, cued memory retrieval strategies and modality switching techniques to effectively increase information processing capacities in complex environments under stressful, operationally realistic conditions.
  - Ruggedized the system to enable the assessment and enhancement of warfighter performance for an order-of-magnitude improvement in operator efficiency.
  - Demonstrated ruggedized, operational prototypes for transition to service components.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

R-1 Line Item No. 12

Page 27 of 28

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 12

Page 28 of 28

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research				<b>R-1 ITEM NOMENCLATURE</b> Biological Warfare Defense PE 0602383E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	132.814	112.814	99.137	106.982	110.914	110.414	110.414	110.414
Biological Warfare Defense Program BW-01	132.814	112.814	99.137	106.982	110.914	110.414	110.414	110.414

**(U) Mission Description:**

(U) DARPA’s Biological Warfare Defense project is budgeted in the Applied Research Budget Activity because its focus is on the underlying technologies associated with pathogen detection, prevention, treatment and remediation. This project funds programs supporting revolutionary new approaches to biological warfare (BW) defense and is synergistic with efforts of other government organizations.

(U) Efforts to counter the BW threat include countermeasures to stop pathophysiologic consequences of biological or chemical attack, host immune response enhancers, medical diagnostics for the most virulent pathogens and their molecular mechanisms, tactical and strategic biological and chemical sensors, advanced decontamination and neutralization techniques, and integrated defensive systems. This program also includes development of a unique set of platform technologies that will dramatically decrease the timeline from military threat detection to countermeasure availability.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Unconventional Therapeutics	37.202	35.000	30.000	37.864

(U) This thrust is developing unique and unconventional approaches to ensure that soldiers are protected against a wide variety of naturally occurring, indigenous or engineered threats. Past successes in this effort have come from developing therapeutics that are designed to work against broad classes of pathogens. This has led to several significant transitions, a separate thrust in Anthrax countermeasures, and most recently a program at Defense Threat Reduction Agency (DTRA) that directly capitalizes on previous DARPA investments. Work in this area has also

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Biological Warfare Defense PE 0602383E	

uncovered new approaches to therapeutics that, rather than attacking specific pathogens, enhance innate human immune mechanisms against broad classes of pathogens. Not only will these approaches be more effective against known pathogens, they also promise to offer substantial protection against unknown pathogens including engineered pathogens and emerging pathogens from third-world environments. An emphasis is on the discovery and development of technologies that will allow a rapid response (within weeks) to unanticipated threats, whether they are naturally encountered emerging diseases or agents from intentional attack. A variety of approaches will be developed to accelerate the capability to rapidly produce needed therapeutics for our warfighters in weeks rather than years. This program has a goal of radically transforming the protein design process by researching and developing new mathematical and biochemical approaches to the in silico design of proteins with specific functions. By determining the structure of a specific protein that binds with a specific pathogen, the manufacturing process for therapeutics will be greatly reduced. This program is also developing an interactive and functional in vitro human immune system using tissue engineering. This “immune system” will be able to test the efficacy of vaccines against threat agents that, at the present time, can only be tested in animal models, thus significantly decreasing the time needed and increasing the probability of success for biological warfare vaccine development. An additional focus is the development of entirely new technologies that will allow the rapid, cost-effective manufacture of complex therapeutic proteins such as monoclonal antibodies and vaccine antigens.

(U) Program Plans:

- Developed in vitro fabrication of three-dimensional tissue constructs, bioscaffolds and bioreactors.
- Develop technologies for nano-imprinting viruses that recapitulate the antigenic structures of the native virus.
- Develop approaches for on-site battlefield synthesis of small molecule therapeutics, including antibiotics.
- Develop technologies to allow rapid, inexpensive assessment of radiation exposure in humans.
- Develop and demonstrate an integrated in-vitro immune system that will emulate the human immune response in order to provide a means of evaluating new BW vaccines and therapeutics.
- Demonstrate the ability to predict known vaccine immunogenicity in humans solely by testing in the artificial immune system.
- Develop and validate new in vitro systems to predict toxicology of vaccines and immune modifiers.
- Develop a technical framework for the synthesis of millions of doses of a protein therapeutic within 12 weeks.
- Develop new approaches for rapid, high-yield synthesis of therapeutic proteins in bacteria, fungi, and yeast.
- Develop new methods for purification of therapeutic proteins from high-yield fermenters.
- Develop new approaches for assuring correct folding and mammalian post-translational modification of proteins by bacteria and fungi.

UNCLASSIFIED

R-1 Line Item No. 13

Page 2 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Biological Warfare Defense PE 0602383E	

	FY 2006	FY 2007	FY 2008	FY 2009
External Protection	15.500	16.542	15.137	18.118

(U) This program is developing and demonstrating a variety of external protection technologies to protect soldiers from the hazards of chemical, biological and radiological attack and other hazards such as large unstable weapons stores. The program includes the autonomous detection and self-cleaning of surfaces contaminated by an attack, and the safe neutralization of hazardous materials.

(U) Program Plans:

- Developed and demonstrated new approaches for decontamination of sensitive electronics.
- Develop and demonstrate active coatings that can be applied to surfaces to provide protection against chem-bio attacks.
- Develop and demonstrate a portable system to safely destroy chemical and biological warfare (CBW) stockpiles.
- Develop and demonstrate a microbial based demilitarization of such hazardous materials as explosives stockpiles.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Diagnostics	7.854	12.572	14.000	19.000

(U) In the early stages, many illnesses caused by biological warfare (BW) agents have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The advanced diagnostics program will develop the capability to detect the presence of infection by biological threat agents, differentiate them from other pathogens (including those of non-BW origin), and identify the pathogen even in the absence of recognizable clinical signs and symptoms (i.e., while the pathogen numbers are still low). Novel approaches including the use of breath and advanced mathematical analysis will be examined.

(U) Program Plans:

- Develop hyperspectral approaches for presymptomatic diagnosis of exposure to pathogens or other medical issues (including naturally occurring disease) that affect soldier health and performance.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E	

- Validate the presence of explosive volatiles in breath in the presence of a number of confounder variables.
- Adapt biosensors for breath-based diagnostics.
- Evaluate and demonstrate multiplexed pathogen detection in microliter samples.
- Demonstrate the capability to mechanically and reversibly alter a protein structure so as to alter the sensitivity and specificity of analyte detection.
- Develop new mathematical and diagnostic approaches to interpret biosignature data from individuals to determine if there will be a change in physiological status from health to disease and vice versa. Use these data to identify the kind of disease and need for treatment.

	FY 2006	FY 2007	FY 2008	FY 2009
Sensors	41.706	30.000	25.000	25.000

(U) The Sensors program goal is to develop a unique set of biological warfare (BW) sensors that will greatly improve sensitivity and response time to bacteria, viruses and/or toxins.

(U) The overall goal of DARPA’s Handheld Isothermal Silver Standard Sensor (HISSS) program is to develop a sensor that is capable of detecting the entire biological warfare threat spectrum (bacteria, DNA viruses, RNA viruses and protein toxins) with the same “silver standard” specificity as current laboratory techniques, but in a fast, reliable, handheld unit. Today, this standard is achieved for DNA and RNA threats using polymerase chain reaction, which is slow because of the associated temperature cycling. For proteins, the standard is met using Enzyme Linked Immunosorbent Assay (ELISA), which requires skilled laboratory technicians to complete. The equipment required for these tests is bulky and difficult to use under field conditions. Under HISSS, DARPA will develop fundamentally new ways to exploit previously developed identification mechanisms (DNA and RNA primers, protein antibodies) in an integrated, isothermal system that will allow a single, handheld sensor to detect the full range of BW threats.

(U) The Spectral Sensing of Bio-Aerosols (SSBA) program involves the active probing of bioaerosols with electromagnetic (EM) energy, which holds the promise of extremely fast, and potentially long-range, detection and identification of bio agents. Only a small portion of the EM spectrum is exploited in today’s trigger sensors (e.g., optically based particle sizers, sometimes enhanced with fluorescence measurements).

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Biological Warfare Defense PE 0602383E	

However, anecdotal evidence suggests that other portions of the spectrum may offer substantial improvement in trigger sensors, as well as potentially agent-specific discrimination capability. Various types of spectra in the visible, infrared, and ultraviolet (UV) wavelengths are being measured for prototype systems development. Additional spectral information such as UV fluorescence lifetime and single particle mass spectroscopy is also being evaluated. DARPA is investing in these approaches, beginning with cross-spectrum data collection and performance models, followed by prototype sensor development. An aerosol testbed has been developed to provide calibrated exposures of threat agent simulants and complex clutter mixtures for sensor performance evaluation.

(U) Program Plans:

- Spectral Sensing of Bio-Aerosols
  - Downselected to most promising concepts.
  - Designed, built, and tested prototype sensor systems.
  - Evaluated the use of mass spectrometry for single particle identification and evaluated the use of multi-spectral fluorescence for stimulant identification in bulk.
  - Characterize sensor prototype behavior in operational environments against live bio-agent aerosols.
  - Characterize other prototype behavior in operational environments against agents.
  
- Handheld Isothermal Silver Standard Sensor
  - Designed a prototype HISSS device.
  - Developing stabilized reagents for fieldability.
  - Build prototype HISSS device.
  - Characterize HISSS prototype in laboratory and operational environments.
  - Test HISSS prototype against live threat agents.

UNCLASSIFIED

R-1 Line Item No. 13

Page 5 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E	

	FY 2006	FY 2007	FY 2008	FY 2009
Threat Agent Cloud Tactical Intercept Countermeasure (TACTIC)	12.500	10.000	10.000	4.000

(U) The TACTIC program will develop and demonstrate the capability to (1) rapidly detect, discriminate and identify an airborne chemical warfare agent/biological warfare agent (CWA/BWA) battlefield threat at stand-off distances, and (2) use countermeasures to neutralize and/or precipitate the threat before it reaches the targeted troops. This program will investigate identification methodologies including: bead-based assays for biological molecules, fluorescent assays for chemicals, retro-reflector assays for chemical and biological agents; all of which can be interrogated with stand-off optical detectors. To accomplish the removal of the threat, technologies that mimic the seeding of rain clouds will be developed for particulate bio-agents, and technologies that react with chemical agent vapor will be investigated. Upon successful demonstration of the identification and removal technologies, a system will be developed to demonstrate the removal of chemical and biological simulant clouds from the battlefield.

(U) Program Plans:

- Investigated technologies for CWA/BWA standoff assays that rapidly (within one minute) identify agents.
- Investigated technologies to remove the agent cloud so as to eliminate the threat to unprotected war-fighters.
- Tested detection assays and cloud removal technologies in large scale test chambers. Validated levels of detection and elimination that will enable an effective TACTIC system.
- Developed models of identification and removal technologies. Carried out systems trades between competing identification and removal technologies.
- Integrate optimal identification and removal components into a prototype system.
- Test prototype system in scaled aerosol test chambers.
- Demonstrate system in full-scale field trials.
- Transition to Joint Program Executive Office - Chem Bio Defense (JPEO-CBD).

**UNCLASSIFIED**

R-1 Line Item No. 13

Page 6 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Biological Warfare Defense PE 0602383E	

	FY 2006	FY 2007	FY 2008	FY 2009
Mission-Adaptable Chemical Sensors (MACS)	10.652	7.700	5.000	3.000

(U) At present, chemical sensors are unable to combine sensitivity (parts-per-trillion) and selectivity (unambiguous identification of molecular species) with low false alarm rate. This effort will develop a sensor, based upon rotational spectroscopy of gases that will have superior capability in all categories; it will achieve the highest possible sensitivity (parts-per-trillion) for unambiguous detection of all chemical species. A preliminary blind test showed complete and unambiguous identification with a sampling time of one second and a false alarm probability below 0.001%. At present, the program has investigated the nature of the atmospheric background “clutter” at the parts per billion (ppb) level and below to enable the identification of target signatures at highest sensitivity. The program will focus on reduction of size and simplicity of function to achieve portability and simultaneous detection of a large number (hundreds) of species. The capabilities will far surpass all other current sensors.

(U) Program Plans:

- Design and build a portable form factor, high-sensitivity chemical sensor system and demonstrate its performance in a high-clutter atmospheric background.
- Demonstrate fractionation and related improvements to the system for improved simultaneous identification of multiple species in seconds.
- Refine initial form factor design and build a compact, fully portable, high-sensitivity sensor system.

	FY 2006	FY 2007	FY 2008	FY 2009
Immune Buildings (IB)	2.500	0.000	0.000	0.000

(U) DARPA has developed technologies for integrated defensive systems to be employed in military buildings to protect and respond to the emerging threat of aerosolized Chemical, Biological and Radiological (CBR) releases. The approach was to modify and augment the infrastructure of buildings to allow them to sense and defeat an attack by biological or chemical agents in real-time and to find and remove hazardous radiation left behind by a “dirty bomb.” The program’s emphasis areas were: to protect the human inhabitants from the effects of the agents; to restore the building to function quickly after the attack; and to preserve forensic evidence for treatment of victims, and for attribution.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E	

For CB releases, the DARPA focus was on the challenging problem of protection from internal releases of agent, where active and timely control of airflow is required to prevent a building’s HVAC system from spreading the agent throughout the building. To enable such building-protection systems, DARPA developed component technologies such as optimized filtration systems, advanced neutralization techniques, and remediation techniques appropriate to biological, chemical, and radiological decontamination. These systems have transitioned for military use via a full-scale demonstration of a complete building protection system. In addition, a software tool was developed that demonstrates the design and optimization of building-protection systems for other military facilities.

(U) Program Plans:

- Continued development of neutralization technologies and reduced-false-alarm CW and BW sensors.
- Characterized the demonstration site facility and developed a prototype active protection system optimized for that site.
- Validated toolkit predictions in full-scale test beds and at demonstration site.
- Extended the software toolkit to provide cost analysis of protective system and further validate with performance and cost data from the demonstration site.
- Developed technologies to hyper-accelerate description of radioactive contamination within building materials and to rapidly mobilize the contamination of outer building surfaces for more efficient removal.
- Installed complete IB protective system in an active military facility at Ft. Leonard Wood, MO.
- Transitioned IB systems to the U.S. Army Chemical School and U.S. Army Corps of Engineers.

	FY 2006	FY 2007	FY 2008	FY 2009
Asymmetrical Products for BWD	1.300	0.000	0.000	0.000

(U) Program Plans:

- Continued to develop a technical approach to induce mucosal immunity against BioWarfare (BW) pathogens. Modeled and synthesized a cytokine-based family of compounds that stimulates mucosal immunity.
- Identified likely cytokine molecules and their combinations that result in resistance to pathogens.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007		
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Biological Warfare Defense PE 0602383E		

	FY 2006	FY 2007	FY 2008	FY 2009
Noninvasive Biomodulation	2.100	0.000	0.000	0.000

- (U) Program Plans:  
 – Demonstrated new non-invasive approaches to biomodulation.

	FY 2006	FY 2007	FY 2008	FY 2009
Specific Gas Detector	0.500	0.000	0.000	0.000

- (U) Program Plans:  
 – Developed a set of proven, highly sensitive and selective sensors for detecting toxic chemical gases in the HVAC systems of buildings critical to Government operation.

	FY 2006	FY 2007	FY 2008	FY 2009
Novel Sensor for Chemical and BioDefense	1.000	0.000	0.000	0.000

- (U) Program Plans:  
 – Developed novel sensors for chemical and biodefense.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E	

	FY 2006	FY 2007	FY 2008	FY 2009
Detecting Emerging Classes of Explosives	0.000	1.000	0.000	0.000

- (U) Program Plans:  
 – Explore technologies for emerging classes of explosives.

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	148.108	112.242	110.695	110.618
Current Budget	132.814	112.814	99.137	106.982
Total Adjustments	-15.294	0.572	-11.558	-3.636
Congressional program reductions	-10.000	-0.428		
Congressional increases	0.000	1.000		
Reprogrammings	-1.500			
SBIR/STTR transfer	-3.794			

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Biological Warfare Defense PE 0602383E	

(U) **Change Summary Explanation:**

FY 2006                      The decrease reflects the SBIR/STTR transfer, a \$10 million decrease to the Immune Buildings program for the Section 8040 rescission and a \$1.5 million below threshold reprogramming.

FY 2007                      The increase reflects a congressional add for Detecting Emerging Classes of Explosives offset by a decrease for Section 8106 Economic Assumptions.

FY 2008/09                  The decreases reflect program repricing.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

R-1 Line Item No. 13

Page 11 of 12

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 13

Page 12 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	337.210	359.936	374.717	436.842	475.935	482.565	508.987	522.565
Naval Warfare Technology TT-03	44.116	38.015	26.676	35.440	45.490	45.490	45.490	45.490
Advanced Land Systems Technology TT-04	62.491	72.221	71.466	84.509	86.979	93.809	93.809	93.809
Advanced Tactical Technology TT-06	111.199	111.706	127.550	136.351	145.256	145.256	145.256	145.256
Aeronautics Technology TT-07	59.179	69.927	76.326	98.576	105.752	105.752	132.174	145.752
Network Centric Enabling Technology TT-13	60.225	68.067	72.699	81.966	92.458	92.258	92.258	92.258

**(U) Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Advanced Tactical Technology, Aeronautics Technology and Network Centric Enabling technologies.

(U) The Naval Warfare Technology project develops advanced enabling technologies for a broad range of naval requirements. The Friction Drag Reduction program will develop friction drag reduction technologies for surface ships and submersibles. The Surface Warfare Automated Shiphandling program will develop technologies to increase survivability and operational effectiveness of small and medium surface vessels in rough seas. The Hypersonics Flight Demonstration program is a joint Navy/DARPA effort that will develop and demonstrate advanced technologies for hypersonic flight. The High Efficiency Distributed Lighting program will change the fundamental design for lighting systems, resulting in increased warship maintainability and survivability. New areas to be investigated are ship self defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations and predictive tools for small craft hydrodynamic design.

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E	

(U) The Advanced Land Systems project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire.

(U) The Advanced Tactical Technology project is exploring the application of compact and solid state lasers; high performance computational algorithms to enhance signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; precision optics components for critical DoD applications; aerospace electronic warfare systems; new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, and enabling technologies for advanced space systems; and a Training Superiority program that will create revolutionary new training techniques.

(U) The Aeronautics Technology project explores technologies to reduce costs associated with advanced aeronautical systems and provide revolutionary new capabilities for current and projected military mission requirements. This project funds development of micro adaptive flow control technologies; small-scale propulsion system concepts; and a high-strength, low structural weight airlift vehicle designed to control its buoyant lift independently of off-board ballast. New areas to be investigated are reusable hypersonic vehicles; novel helicopter blade designs that reduce acoustic signature; small, low cost high endurance UAV's capable of destroying most enemy UAV's; and short distance take off and landing of fixed wing aircraft.

(U) The Network Centric Enabling Technology project funds sensor, signal processing, detection, tracking and target identification technology development required for true network-centric tactical operations. Technologies developed in this project will enable localized, distributed and cross-platform collaborative processing so that networks of sensors can rapidly adapt to changing force mixes, communications connectivity and mission objectives. Operational benefits will be smaller forward deployment of image and signal analysts, consistent integration of target and environment information, and flexible operational tactics and procedures for finding evasive targets in difficult environments.

UNCLASSIFIED

R-1 Line Item No. 16

Page 2 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E	

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	346.076	383.680	448.165	493.591
Current Budget	337.210	359.936	374.717	436.842
Total Adjustment	-8.866	-23.744	-73.448	-56.749
Congressional program reductions	0.000	-36.224		
Congressional increases	0.000	12.480		
Reprogrammings	0.000			
SBIR/STTR transfer	-8.866			

(U) **Change Summary Explanation:**

FY 2006	Decrease reflects the SBIR/STTR transfer.
FY 2007	Decrease reflects a PE execution adjustment, congressional program reductions, reductions for Sections 8023 and 8106, offset by congressional adds for CEROS, hypersonics, hazardous materials detection, optical sensor systems, extreme light sources, and NASEC.
FY 2008/09	Decreases reflect programs ending or transitioning in Naval Warfare Technology (HyFly, Hedlight, SWASH), Advanced Land Systems Technology (NetEx, Sticky Flares), Aeronautics Technology (Hypersonics Demonstration), and rephasing of Network Centric programs.

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**  
R-1 Line Item No. 16  
Page 4 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research				<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Naval Warfare Technology TT-03	44.116	38.015	26.676	35.440	45.490	45.490	45.490	45.490

**(U) Mission Description:**

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. Enabling and novel technologies include concepts for expanding the envelope of operational naval capabilities such as drag reduction, hypersonic missiles, logistically friendly distributed lighting systems, ship self defense techniques, novel underwater propulsion modalities, vessels for estuary and riverine operations, acoustic anti-submarine warfare and predictive tools for small craft hydrodynamic design.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Friction Drag Reduction	7.289	5.125	3.700	2.635

(U) The Friction Drag Reduction program will develop and demonstrate physics-based, engineering design tools that will predict additive-based friction drag reduction on Navy surface ships. Such a capability would result in decreases in fuel usage, increases in burst speed, and enhancements in vehicle range and endurance. To date, the program has developed the capability to predict how turbulent flows are modified by the presence of polymers and air injection. These models were validated with small-scale physical experiments and tests in a large scale facility at ship-relevant scales. The predictive capability has been tested using an optimized injector in a blind-test of the design tool in large scale experiments conducted on a 13 meter long flat plate at the U.S. Navy's William B. Morgan Large Cavitation Channel, with separate tests for the polymer and air injection. Additionally, polymer and air film injection was tested to simulate the surface roughness that would be caused by biofouling of surface vessel hulls. These large-scale predictive models and tests will be used to design an optimal implementation of additive-based drag reduction technology for a realistic at-sea test (e.g., small surface ship).

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03	

- (U) Program Plans:
- Verified predictive capabilities of air and polymer injection models.
  - Experimentally determined how additive-based friction drag reduction is influenced by the presence of significant surface roughness.
  - Evaluate concepts for a realistic at-sea test using additive-based drag reduction technology.
  - Conduct initial design at-sea demonstration to evaluate sea states, maneuvering conditions, biofouling, ship curvature and pressure gradients on injection based drag reduction approaches.
  - Determine how drag reduction and air film onset scales with speed of vessel in at-sea demonstrations.

	FY 2006	FY 2007	FY 2008	FY 2009
Surface Warfare Automated Shiphandling (SWASH)	2.800	2.728	0.000	0.000

(U) The Surface Warfare Automated Shiphandling (SWASH) program is developing and demonstrating technologies to increase survivability and operational effectiveness of small and medium naval surface vessels in rough seas. Currently, vessels are at the mercy of ocean waves, and when waves become sufficiently large, damage and capsizing can occur. SWASH is seeking to enable safe operations in an expanded sea state envelope by combining detailed wave sensing and prediction with improved understanding of vessel dynamics in a control system that provides optimum course and speed to the vessel's rudder and engines. SWASH technology offers the potential to reduce injuries to crew and passengers as well as damage to vessels caused by high waves and represents an enabling technology for unmanned surface vessels (USVs) by increasing survivability, recoverability and operability.

- (U) Program Plans:
- Refine prediction capability for ocean wave fields.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03	

	FY 2006	FY 2007	FY 2008	FY 2009
Hypersonics Flight Demonstration (HyFly)	11.882	5.476	0.000	0.000

(U) The Hypersonics Flight Demonstration program (HyFly) will develop and demonstrate advanced technologies for hypersonic flight. Flight-testing will be initiated early in the program and progress from relatively simple and low-risk tests through the demonstration of an increasingly more difficult set of objectives. The ultimate goals of the program are to demonstrate vehicle performance leading to a tactical surface launched missile range of 600 nautical miles. Specifically the program will demonstrate an F-15 launched missile configuration with a range of 400 nautical miles with a block speed of 4,400 feet per sec, maximum sustainable cruise speed in excess of Mach 6, and the ability to accurately terminate the missile on a GPS guided impact target. Technical challenges include the scramjet propulsion system, lightweight, high-temperature materials for both aerodynamic and propulsion structures, and guidance and control in the hypersonic flight regime. Recently demonstrated performance in ground testing of the dual combustion ramjet engine coupled with advances in high temperature, lightweight aerospace materials are enabling technologies for this program. The core program will focus on development and demonstration of capabilities requisite for an operational weapon. A separate effort will be performed in parallel to demonstrate advanced propulsion technologies and develop low-cost test techniques. DARPA and the Navy have established a joint program to pursue areas of the hypersonics program that would be relevant to maritime applications.

(U) Program Plans:

- Conducted captive carry, drop, boost performance and boost separation flight tests.
- Performed vehicle subsystems verification testing.
- Conduct flight weight vehicle environmental testing.
- Conduct flight weight engine component durability testing in operating engine environment.
- Conduct initial, low flight Mach (~Mach 4.0) flight-testing.
- Demonstrate Mach 6.0 cruise and extended range (400 nm).

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03	

	FY 2006	FY 2007	FY 2008	FY 2009
High Efficiency Distributed Lighting (HEDLight)	2.354	1.000	0.000	0.000

(U) The High Efficiency Distributed Lighting (HEDLight) program seeks to fundamentally change the design for lighting systems on U.S. military platforms to increase survivability, deployability, and maintainability. Current lighting systems use electrical distribution and the generation of light at the point-of-use. HEDLight remote source lighting uses centralized light generation and optically transports the light to the point-of-use. This allows the lighting system electrical circuitry and wiring to be concentrated, protected, and removed to the interior of the warship, thereby removing a source of vulnerability from the outer-envelope. Critical metrics that are necessary for the successful implementation of HEDLight are system efficiency, weight, and control of the illumination pattern. The technical areas key to the success of the HEDLight program include the development of compact, high-efficiency, full-spectrum light sources; high-efficiency coupling optics; high-efficiency, integrated optical-fiber luminaries; and integrated illuminator engines that effectively combine the light source, the optical coupler, and fiber-luminaire. A Memorandum of Agreement (MOA) is in place to transition this technology to the Navy. An adjunct to the HEDLight program developed and demonstrated a state-of-art Assault Zone Landing Light, which solved the logistics and reliability issues of currently deployed lights.

(U) Program Plans:

- Developed high efficiency full-spectrum light sources.
- Developed high efficiency optical coupling mechanisms.
- Developed high efficiency fiber-luminaries for distributed light transport.
- Developed an integrated high efficiency distributed lighting illuminator.
- Demonstrate a limited scale HEDLight system installed on a U.S. Navy ship.
- Developed and demonstrated the L-32 Assault Zone Landing (AZL-15) Lights, meeting the minimum lighting (visible and IR) and battery duration requirements and tested all system variations under operational field conditions.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03	

	FY 2006	FY 2007	FY 2008	FY 2009
Center of Excellence for Research in Ocean Sciences (CEROS)	6.250	5.600	0.000	0.000

(U) The Center of Excellence for Research in Ocean Sciences (CEROS) encourages leading edge research and development in ocean sciences, by involving highly specialized small businesses with recognized expertise in ocean related research, and providing access to potential Department of Navy transition partners. Major research areas of interest have included shallow water surveillance technologies, sensor communications, ocean environmental preservation, new ocean platform and ship concepts, ocean measurement instrumentation, and unique properties of the deep ocean environment.

(U) Program Plans:

- Select projects for funding.
- Contract selected projects and monitor progress of ocean related technologies of high interest to the DoD.
- Transition appropriate products to military use.

	FY 2006	FY 2007	FY 2008	FY 2009
Acoustic Arrays for Torpedo Defense	0.760	2.000	1.306	0.000

(U) The Acoustic Arrays for Torpedo Defense program will demonstrate the feasibility of using an array of transducers to form a destructive pressure pulse capable of disabling an enemy's torpedo. Of critical importance is the ability to accurately predict non-linear pressure pulse propagation effects and corresponding timing delays used during pressure pulse generation and beamforming. Additionally, the beamformed pressure pulse must be of sufficient amplitude and duration to destroy a torpedo at tactically significant ranges.

(U) Program Plans:

- Designed, developed, and tested a two transducer module.
- Completed design improvements on second generation transducer module.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03	

- Successfully tested second generation transducer module.
- Develop scaled prototype transducer array.
- Conduct prototype system testing.

	FY 2006	FY 2007	FY 2008	FY 2009
Unique Propulsion Techniques	1.238	3.273	1.000	1.200

(U) The Unique Propulsion Techniques program will develop a novel underwater propulsion technology for Unmanned Underwater Vehicles (UUV) and other underwater platforms that require high maneuverability at low velocities. The propulsion mechanism of the electric eel may hold the key to this enabling technology. Electric eels using ribbon fin propulsion may be generating traveling chains of ring vortices, which give more momentum transfer than simply pushing the same quantity of fluid with no structure. The objective of the program is to develop a ribbon fin propulsion system and demonstrate the increased low velocity power efficiency and maneuverability of an actual underwater platform. The fundamental technical challenges include 1) determining if the traveling wave is structured to maximize thrust, 2) determining the structure of the fluid flow imparted by the ribbon fin, 3) determining how to implement a flexible ribbon structure with sufficient power and controllability to be useful, and 4) determining how to attach such a structure to a rigid body and integrate it with other control surfaces to gain additional degrees of freedom.

- (U) Program Plans:
- Accurately model the physics of ribbon fin propulsion and create predictive design tools.
  - Design and demonstrate a ribbon fin propulsion system on an appropriately scaled surrogate platform.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03	

	FY 2006	FY 2007	FY 2008	FY 2009
Riverine Crawler Underwater Vehicle	2.458	2.613	2.500	1.500

(U) The Riverine Crawler Underwater Vehicle program will study means of operating in challenging conditions of obstructions, turbidity and current such as in rivers and harbors by an unmanned submerged craft. Novel means of navigation, propulsion and sensing will be required to operate autonomously in such environments.

(U) This program will explore the potential concepts and the technologies necessary to perform these missions. The effort will identify the promising vehicle types and examine the system and/or component element technologies required to support these vehicles.

(U) Program Plans:

- Perform concept of operations (CONOPS) studies; set the basis of the technology survey, vehicle concept applicability evaluation and the process for identifying vehicle system and component technology concepts.
- Identify technologies to address various challenges that a set of defined vehicle types and sensor payloads must face in the riverine environment and what possible forms the vehicle could take in order to address each of the mission challenges.

	FY 2006	FY 2007	FY 2008	FY 2009
Fast Boat (formerly Small Craft Advanced Hydrodynamic Design)	3.085	0.000	0.000	0.000

(U) The goal of the Fast Boat program was to design, and demonstrate one or more boats with threshold speeds of 60 knots and an objective speed of 100 knots in high sea states with a ride quality that is a significant improvement over existing boats.

(U) The program addressed design requirements for both high speed and good ride quality in sea states 3-5 and investigated the operational benefit of high speed in special operations.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03	

- (U) Program Plans:
- Completed system trade studies and preliminary design.

	FY 2006	FY 2007	FY 2008	FY 2009
Super-Fast Submerged Transport (formerly Underwater Express)	6.000	8.000	12.100	21.000

(U) The Super-Fast Submerged Transport (formerly Underwater Express) program will explore the application of supercavitation technology to underwater vehicles, enabling high speed transport of personnel and/or supplies. The inherent advantages of traveling underwater are: the ability to transit clandestinely, (no radar or visible signature), and avoidance of rough sea conditions that may limit or deny mission execution. Supercavitation places the vehicle inside a cavity where vapor replaces the water, and drag due to fluid viscosity is reduced by orders of magnitude, thus reducing the power requirement dramatically. This program will use modeling, simulation, and experiments and testing to develop the understanding of the physical phenomena associated with supercavitation and the application to underwater vehicles. Innovative failsafe controls will be required for stability and maneuverability at speed. Elements of the Fast Boat program have been incorporated in the Underwater Express program.

- (U) Program Plans:
- Develop models and simulations to predict cavity and cavitator performance.
  - Conduct subscale experimentation and testing in a controlled facility.
  - Conduct subscale experimentation and testing for system stability and control.
  - Design, fabricate and test a scaled prototype vehicle.
  - Analyze prototype performance for speed, power, and stability. Develop vehicle and cavity scaling relationships.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03	

	FY 2006	FY 2007	FY 2008	FY 2009
Wideview	0.000	2.200	3.500	3.500

(U) This program will exploit a technology used successfully by the underwater acoustic community and convert it to give tactical aerial vehicles the ability to continuously detect, locate and track battlefield sounds (such as sniper firing) over a whole 360° field of view.

(U) Program Plans:

- Measure airborne towed array noise.
- Adapt current capabilities from water to the higher speeds of air vehicles. Perform system analysis to assure compatibility of towed arrays with UAV performance.
- Develop acoustic models through computational techniques and limited airborne testing to account for background clutter. Assure fires detection range at least 10km from UAV at 5,000 feet, and the tracking of combat vehicle noise at a similar range.
- Develop a prototype system.

	FY 2006	FY 2007	FY 2008	FY 2009
Distortion-free Seeing Through the Air/Water Interface	0.000	0.000	2.570	5.605

(U) Images seen through an air-water interface are distorted by multiple refractions from the water surface. This program will develop and demonstrate high resolution imaging and image exploitation technology to provide new capabilities for detection and discrimination of objects such as mines. This effort, if successful, could significantly improve near-surface operations and safety. Transition will be focused on Navy Special Warfare forces.

(U) Program Plans:

- Conduct experiments and scale testing of imaging algorithms.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-03	

- Develop imaging system, characterize resolution, image quality, and performance in various water qualities.
- Design, develop, and test a prototype system.

**(U) Other Program Funding Summary Cost:**

	FY 2006	FY 2007	FY 2008	FY 2009
Hypersonics Flight Demonstration				
PE 0602114N, PE 0603114N, PE 0603123N, Navy, Office of Naval Research	11.300	2.200	0.000	0.000

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research				<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Advanced Land Systems Technology TT-04	62.491	72.221	71.466	84.509	86.979	93.809	93.809	93.809

**(U) Mission Description:**

(U) This project is developing technologies for enhancing U.S. military effectiveness and survivability in operations ranging from traditional threats to military operations against irregular forces that can employ disruptive or catastrophic capabilities, or disrupt stabilization operations. The emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of U.S. or allied forces to enemy fire. This project consists of the following programs: Novel Sensors for Force Protection; Dynamic Optical Tags (DOTS); Guided Projectiles; Networking Extreme Environments (NetEx); MAGneto Hydrodynamic Explosives Munition (MAHEM); Compact Military Engines; Crosshairs; Improved Explosives; Agile Interceptor; Counter Improvised Explosives Laboratory (CIEL); Maneuver and Control on the Urban Battlefield, Advanced Vehicle Survivability (AVES), Turbo-Compounded Rotary (TCR), Recognize Improvised Explosive Devices and Report (RIEDAR), Lightweight Ceramic Armor (LCA), Small Combat Vehicle with Robotic Automation, Army Hypersonic Advanced Technology, Extreme Light Sources for Defense Applications, Optical Sensor System, Research on a molecular approach to HazMat Decontamination and RF Counter Sniper.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Novel Sensors for Force Protection	12.237	15.992	12.313	12.438

(U) The Novel Sensors for Force Protection program is exploring and developing a variety of novel methods that will contribute to enhanced protection of U.S. warfighters and address hostile situations encountered by U.S. warfighters in the Global War on Terrorism, Operation Enduring Freedom and Operation Iraqi Freedom. The motivation behind all of the programs is to reduce the exposure of U.S. warfighters when they are operating in disadvantageous territory, especially those complex settings (densely populated and structured areas, multi-storied buildings, etc.)

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

typically found in urban settings. The Novel Sensors program consists of the Unique Signature Detection program (formerly known as the Odortype Detection program) and the Urban Vision program.

(U) The objective of the Unique Signature Detection program is to determine, by means of a well-developed scientific methodology, whether there are unique signatures in emanations that can be used to identify and distinguish specific high-level-of-interest individuals within groups of enemy troops or combatants, and if so, to develop enabling technology for detecting and identifying those specific signatures. The program consists of an interdisciplinary team of performers using state-of-the-art techniques to evaluate the statistical, biological and chemical nature of individual emanations. Once the nature of the chemosignal has been characterized, performers will determine the impact of non-genetic factors (e.g., diet, stress, health, age) on the signal in order to determine whether the signal can be robustly extracted from a complex and varied chemical background. If an exploitable robust signature is identified, the program will then pursue detector development.

(U) The goal of the Urban Vision program was to enable the warfighter to 'see' movers within a building using a variety of fused multi-spectral techniques. The objective was to develop a necessary and sufficient number of sensor breadboards that could demonstrate the capability to the user community. The application is in-building take-down operations, where the user enters the building through the roof. The sensors would be placed on the roof to give information on the number and location of occupants in the floor immediately below. The sensors had to be small and light weight. The system had to operate with a minimal number of sensors (the goal is four). Technical challenges included understanding the fundamental physics limitations of various techniques, fusion and developing a combined sensor and networked communications transceivers with required size, weight and power for candidate platforms.

(U) Program Plans:

- Unique Signature Detection
  - Identify the chemical make-up of the Major Histocompatibility Complex (MHC)-determined unique signatures.
  - Examine the chemistry and impact of non-genetic background signals and develop receiver operator curves (ROC) for performance.
  - Design detectors that are capable of identifying high-level-of-interest individuals within groups of enemy troops or combatants through unique, specific signatures with high reliability.

UNCLASSIFIED

R-1 Line Item No. 16

Page 16 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

- Urban Vision
  - Designed, developed, and evaluated an initial (fixed placement) multi-static multi-frequency dielectric imaging array test system.
  - Developed algorithms for inverting multi-static imaging data to reveal the interior structure and distribution of objects within a building, and to coarsely categorize those objects as enemy troops or combatants.

	FY 2006	FY 2007	FY 2008	FY 2009
Dynamic Optical Tags (DOTS)	9.766	7.545	3.897	0.000

(U) Based on the technical successes and demonstrated operational relevance of DARPA's now completed Optical Tags program, the Dynamic Optical Tags and Sticky Flares programs seek to create new tagging, tracking, designating, and locating capabilities for U.S. forces. These programs will develop optical tagging, interrogation, and designation technologies that will enable small devices such as environmentally robust, retro reflector-based tags and highly-visible designators that can be read by airborne sensors at significant ranges. These tags can be used for unique, non-radio frequency (RF) identification of items of interest, monitoring tactical areas for disturbance from personnel and vehicles, and designating targets in complex environments. The identification tags also will be capable of providing persistent two-way communications for both tactical and logistics operations.

- (U) Program Plans:
- Demonstrated performance in the field at militarily useful data rates and ranges.
  - Develop novel emplacement technologies.
  - Develop airborne interrogation systems.
  - Integrate and test components in a fully functional configuration.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

	FY 2006	FY 2007	FY 2008	FY 2009
Guided Projectiles	13.721	11.825	3.857	0.000

(U) The Guided Projectiles program is developing and demonstrating highly maneuverable gun-launched projectiles, and associated fire control and launch systems for employment against critical enemy infrastructure and point targets, such as command, control and communication nodes and radars. This program will develop enabling technologies to give U.S. warfighters the ability to allow weapons platforms, such as mortars, to receive updated target information from other munitions or sense target changes on their own. Based upon this information, the accuracy and effectiveness of the weapons are increased and the potential for collateral damage is reduced. This program will adapt recent advances in communications, computers, sensing and propellants/explosives to demonstrate significant leaps in combat capability. The technologies being developed will demonstrate the increased combat effectiveness and the reliability of distributed, collaborative processing and mission execution.

(U) The program will develop a low-cost, non-imaging optical seeker/guidance unit exploiting technology development in the visible and infrared spectrum that will replace the current 60mm mortar fuse to improve firing precision. Additionally, research will be done with explosives to improve the effectiveness of 60mm explosive rounds. The goal is to develop a 60mm projectile with the effectiveness of a 105mm high explosive projectile. In addition, the technology being developed for the 60mm projectile will be investigated for application to the 81mm and 120mm mortars to increase the accuracy and effectiveness of all fielded mortar rounds at a low cost.

(U) Program Plans:

- Develop mortar seeker using an array of non-imaging optical lenses.
- Develop small and responsive mortar guidance/control/steering fin system.
- Integrate seeker with guidance/control/steering system into a unit that replaces the current fuse on the 60mm high explosive mortar.
- Demonstrate guide-to-hit with circular error probability (CEP)<4m for 60mm mortar.
- Demonstrate tube launch of 60mm optically guided mortar round and optical designating system in conjunction with USMC.
- Investigate development path to transfer the 60mm technology to the 81mm and 120mm mortars.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

	FY 2006	FY 2007	FY 2008	FY 2009
Networking Extreme Environments (NetEx)	3.977	4.995	2.000	0.000

(U) The Networking in Extreme Environments (NetEx) program will create a wireless networking technology for the military user that will enable robust connectivity in harsh environments (for example, areas prone to multipath interference such as urban settings where buildings and other structures cause RF energy to “bounce” off, in and amongst the buildings/structures) and support development of new and emerging sensor and communication systems. This program will develop an improved physical layer for networked communications based on a family of new ultra wideband (UWB) devices. These devices will enable reliable and efficient operations in harsh environments by exploiting the unique properties of UWB systems that allow them to work in a dense multi-path environment and to function as both a sensor and communications device. The program will adapt new and emerging ad-hoc routing protocols and multiple access schemes to take advantage of the unique properties of UWB to communicate in harsh environments, to very accurately resolve range, and to act as a radar based sensor.

(U) Program Plans:

- Demonstrated a tactical voice data radio (TVDR) physical layer.
- Developed new and innovative methods of ad hoc networking and mitigating interference.
- Develop a TVDR with ranging.

	FY 2006	FY 2007	FY 2008	FY 2009
Magneto Hydrodynamic Explosive Munition (MAHEM)	5.316	3.135	4.426	4.200

(U) The Magneto Hydrodynamic Explosive Munition (MAHEM) program will demonstrate compressed magnetic flux generator (CMFG)-driven magnetohydrodynamically formed metal jets and self forging penetrators with significantly improved performance over explosively formed jets and fragments. Explosively formed jets (EFJ) and self forging penetrators (SFP) are used for precision strike against targets such as armored vehicles and reinforced structures. Current technology uses chemical explosive energy to form the jets and fragments. This is highly inefficient and requires precise machining of the metal liners from which the fragments and jets are formed. Generating multiple jets or fragments from a

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

single explosive is difficult, and the timing of the multiple jets or fragments cannot be controlled. MAHEM offers the potential for higher efficiency, greater control, the ability to generate and accurately time multiple jets and fragments from a single charge, and the potential for aimable, multiple warheads with a much higher EFJ velocity, hence increased lethality and kill precision, than conventional EFJ/SFP. MAHEM could be packaged into a missile, projectile or other platform and delivered close to target for final engagement and kill. This could provide the warfighter with a means to address stressing missions such as: lightweight active self-protection for vehicles (potential defeat mechanism for a kinetic energy round); counter armor (passive, reactive, and active); mine countermeasures; and anti-ship cruise missile final layer of defense.

(U) Program Plans:

- Complete single CMFG and MAHEM concept designs.
- Develop MAHEM variants tailored to mission-specific requirements.
- Develop and conduct experiment demonstration of a self-contained MAHEM in the form of an AT4 shoulder-mounted munition.
- Conduct aerostability, setback, and jet penetration tests on the AT4 mockup.
- Test Fire from AT4 tube to demonstrate aerostability and setback.
- Transition to munitions development centers.

	FY 2006	FY 2007	FY 2008	FY 2009
Compact Military Engines	2.065	2.430	2.370	1.356

(U) As military systems become more mobile and autonomous, and able to carry out missions with greater endurance, they will require a new generation of engines that are lighter, more compact, and consume less fuel. Further, the military is requiring that the new generation of engines consume only logistic fuel (JP-8). The Compact Military Engines program will apply innovative ideas for engine design to produce performance gains not obtainable by further refinement of conventional designs. The ideas will, for example, eliminate heavy accessory components, such as the valve drive trains, and eliminate sources of lost power, such as piston side forces causing friction and thermal conduction through cylinder walls. The Compact Military Engines program will address various engine types and diverse missions. A goal of the program is to decrease the size of mobile electric power generators by a factor of ten. Improvements to electric generators for hybrid electric vehicles will increase vehicle range and endurance.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

- (U) Program Plans:
- Demonstrate critical technologies.
  - Build and test prototype engines to demonstrate continuous operation at substantial power levels.
  - Build and test prototype engines to demonstrate full performance.

	FY 2006	FY 2007	FY 2008	FY 2009
Crosshairs	7.495	10.900	14.400	17.000

(U) The Crosshairs program seeks to develop a vehicle mounted, threat detection, and countermeasure system that will detect, locate, and engage shooters, and defeat a variety of threats to include bullets, Rocket Propelled Grenades (RPGs), Anti-Tank Guided Missiles (ATGMs), and direct fired mortars, both stationary and on the move. Threat identification and localization will be accomplished in sufficient time to enable both automatic and man-in-the-loop responses. Phase I of the program focused on designing and developing the appropriate Crosshairs sensor system. Phase I culminated with a static live fire test to determine the most effective candidate sensor system. Phase II will focus on the integration of the Phase I sensors onto a military vehicle for on-the-move performance assessment. In addition, the system will be integrated and tested with a remote overhead weapon station with automatic slew to target capabilities. The weapon station will be equipped with visual and IR cameras to provide imaging for forensic and judicial evidence and rapid dissemination of location of combatants for both effective concealment, and counter fire capabilities. Integration with an appropriate active protection system for further protective measures against RPGs will be explored.

(U) The Concept of Operations is to provide a military vehicle with a mounted detection and response system that operates both stationary and on the move. Bullets will be detected and localized using the acoustic DARPA-developed Boomerang II acoustic gunfire detection system. Detection of all other threats will use the Crosscue radar developed in Phase I. Crosscue radar is a dual mode, continuous wave, and pulsed Doppler radar, which will be used to determine range, velocity, and azimuth of the incoming threat. It is envisioned that the system will provide a significantly improved capability to detect and respond to incoming threats during hostile and peacekeeping operations in both urban and non-urban environments. Technology challenges include: low false alarm rate, algorithm development, high speed sensor and data processing for 360 degree azimuth and 60 degree elevation detection zone; robust data collection to locate firing source; and fast response time. The program will culminate with a demonstration of two prototype systems in a typical combat environment.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

- (U) Program Plans:
- Completed Phase I.
  - Identified and developed ultra-fast sensors and algorithms to detect and track multiple threats in near real time.
  - Performed component testing and conducted detection and shooter localization demonstrations.
  - Evaluate vehicle platform and weapon system for integration.
  - Analyze data and integrate sensors and response system with appropriate on the move capabilities.
  - Test system on the move against a variety of threats with integrated response systems.

	FY 2006	FY 2007	FY 2008	FY 2009
Improved Explosives	2.635	0.562	0.000	0.000

(U) The Improved Explosives program explored development of more effective explosive munitions that would deliver three to five times more power (pound-per-pound) than conventional systems. The program evaluated techniques for improving the effectiveness and efficiency of explosive energy, and considered application of such improved explosives to wall/building breaching and improvised explosive device (IED)/ordnance neutralization.

- (U) Program Plans:
- Conducted initial studies, modeling and simulation to determine the feasibility of candidate technologies.

	FY 2006	FY 2007	FY 2008	FY 2009
Agile Interceptor	2.592	5.330	5.994	7.665

(U) The Agile Interceptor program will develop and demonstrate a projectile system to protect limited areas (e.g. 1-2 km square) against mortar / artillery / rocket rounds, and potentially vehicles or helicopters from rocket propelled grenades, man portable air defense systems (MANPADS), and anti-armor rockets (e.g., TOW). The Agile Interceptor will have the ability to maneuver very rapidly and with sufficient

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

accuracy to engage the selected threat types while still remaining affordable. Relative to other options, the Agile Interceptor will be lower cost and will have significantly reduced collateral damage. Program plans will include multi-phased user reviews to ensure that the resulting products are meaningful and affordable. Evaluation of various area and platform defense options will be conducted culminating with a series of capability demonstrations in a realistic test environment.

- (U) Program Plans:
- Define system architecture and constraints in conjunction with user / technical group.
  - Define metrics and evaluate system effectiveness and cost.
  - Develop and demonstrate critical technologies such as efficient lethality mechanisms and lightweight, integrated Guidance Navigation and Control (GNC) systems.
  - Initiate second phase to improve selected technologies and integrate them into the overall interceptor system.
  - Demonstrate live fire intercept of mortars and other selected threats.

	FY 2006	FY 2007	FY 2008	FY 2009
Counter Improvised Explosives Laboratories (CIEL)	1.687	1.567	1.209	1.200

(U) Improvised explosives (IEs) are one of the most popular weapons used by terrorist groups. Over the past 20 years, IEs have become very common due to their easy preparation and the high availability of raw materials. Efficient methods for detecting and neutralizing/desensitizing sensitive explosives labs in an urban environment will minimize interference with troop operations and minimize collateral damages. The goal of the Counter Improvised Explosives Laboratories (CIEL) program is to develop the infrastructure and methodology for novel chemo-sensors that will identify labs that are building IEs to a very high degree of specificity and reliability; and develop the infrastructure for tools for safe handling of improvised explosives and their mixtures.

- (U) Program Plans:
- Develop a chemo-sensor that provides a clear and fast identification of the target explosive.
  - Identify a physical method that will neutralize/desensitize bulk explosive materials.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

- Conduct feasibility demonstrations.
- Optimize and demonstrate the sensor.

	FY 2006	FY 2007	FY 2008	FY 2009
Maneuver and Control on the Urban Battlefield	0.000	2.500	4.300	7.850

(U) This program will develop new, high speed, lightweight, and portable tools including bar cutters, rotary cutters, 5-25 ton spreaders, jamb breakers, deployable personnel barriers, and rooftop access devices. The ultimate program goal is to reduce the weight of existing access tools by 80% as well as deliver new and unique capabilities such as direct and rapid rooftop access and rapidly deployed personnel barriers.

(U) Program Plans:

- Develop lightweight mechanical power sources optimized for the unique duty cycle of equipment that is useful in an urban fight, i.e., 1-2 minute bursts interspersed with idle periods where silence may be at a premium. The goal is to reduce the weight of the energy storage and power conversion system by a factor of ten.
- Develop lightweight versions of access and population control tool end effectors including spreaders, cutters, jamb breakers, personnel barrier dispensers, and rooftop access systems by utilizing lightweight composites and ceramics. Active structural control may also be used to reduce structural mass.
- Combine the new power systems with the end effectors to create a set of unique tools optimized for use in urban combat.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Vehicle Survivability (AVES)	0.000	0.000	3.500	7.800

(U) The Advanced Vehicle Survivability (AVES) program is a system demonstration of advanced survivability technologies (ASTs) on legacy fighting vehicles such as the Bradley and HMMVW. Integration of certain high-power ASTs into legacy vehicles is impossible today, but would be enabled by a new, very-thin-film battery technology. The AVES program would develop a very small integrated extreme power module

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04	

(IEPM) using this battery technology, and demonstrate a deployable AST system installation in live fire testing on a legacy vehicle. The IEPM system would provide high voltage (300/600V) with a pulse power capability of 20kW/module. The IEPM would enable integration of high-power ASTs into small legacy vehicles in the current inventory. Four modules are required (each is smaller than a gallon of milk), and can be mounted into any interior space available (wheel wells, under the hood, under the seats, etc.) or even external on the fenders to provide power for the AST.

(U) Program Plans:

- Develop and integrate power module components – charger, battery, and high-voltage converter.
- Test components in a laboratory environment.
- Integration and packaging of components into a power module.
- Live-fire testing of stand-alone, electromagnetic armor system.

	FY 2006	FY 2007	FY 2008	FY 2009
Turbo-Compounded Rotary (TCR)	0.000	0.000	3.200	6.700

(U) The goal of the Turbo-Compounded Rotary (TCR) Engine program is to achieve a specific fuel consumption (sfc) of 0.34 lb/hp.hr at a specific power (SP) of 3.0 hp/lb through the integration of turbo-compounding, the stratified charge rotary engine operating on a Miller Cycle, new lightweight materials, and rotary core heat loss reduction technologies. The TCR Engine program will enable a new class of both manned and unmanned air and ground vehicles. The concept offers a new approach to integrating the benefits of a rotary engine with new technologies to vastly improve engine performance. With the breakthrough improvement in sfc and SP, the TCR engine technology will enable loiter time improvements that nearly double that achieved using simple turbo-shaft powerplants. Additionally, the power density goal exceeds the current target for aero-diesel engines by 300%. Specific objectives of the TCR Engine program include: application of the Miller Cycle to a highly turbocharged rotary core; development of stratified charge combustion; analytical investigation of the benefits of high speed operation to this engine configuration; integration of high temperature cooling system; as well as investigation and test of lightweight materials in both the rotary core and turbomachinery.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

- (U) Program Plans:
- Validate engine performance goals and produce a conceptual design.
  - Identify and develop the critical technologies required to meet the performance goals.
  - Build and demonstrate the integrated engine.

	FY 2006	FY 2007	FY 2008	FY 2009
Recognize Improvised Explosive Devices and Report (RIEDAR)	0.000	0.000	3.000	6.800

(U) The goal of the Recognize Improvised Explosive Devices and Report (RIEDAR) program is to develop and demonstrate a capability for standoff detection of improvised explosive devices. The program will leverage laser-based optical approaches to detect chemical signatures of explosives and related compounds.

- (U) Program Plans:
- Prevent UV photo-degradation during laser excitation.
  - Rapidly match wavelengths to interrogate molecules of interest in a specific area.
  - Maintain coherent cross beam stability.
  - Limit signal integration time.
  - Control filament at interrogation area.

	FY 2006	FY 2007	FY 2008	FY 2009
Lightweight Ceramic Armor (LCA)	0.000	0.000	4.500	7.500

(U) The Lightweight Ceramic Armor (LCA) program will leverage recent breakthroughs in novel ceramic fabrication processes developed in the Materials Technology program element to drive a dramatic shift in the performance of body armor. Currently fielded body armor is heavy and limited in the diversity of shapes that may be molded. Its weight and bulk prohibit consideration of protecting a soldier's extremities, and its cost

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

prohibits consideration of using it to protect vehicles. Recent breakthroughs in ceramics processing technology offers the opportunity for cost effective fabrication of molded shapes, the retention of nanostructured grains for significantly higher energy dissipation, a 50% reduction in weight for equal ballistic protection, and similar cost. The focus areas of the program will be the optimization of the material composition and nanostructure for maximum protection per unit weight and cost, scale up of the fabrication technology to body armor size scale, and integration of the ceramics with packaging structures to obtain multi-strike capabilities. Given its application-specific focus, this program is now being funded in the Tactical Technology program element.

(U) Program Plans:

- Develop Lightweight Ceramic Armor with high dynamic tensile stress to effectively dissipate shock waves.
- Reduce armor thickness in order to increase soldier's agility.
- Deliver Lightweight Ceramic Armor at a cost equal or similar to current armor selection.
- Design Lightweight Ceramic Armor to provide protection to soldier's extremities.
- Conduct ballistic testing to demonstrate improved ballistic efficiency.

	FY 2006	FY 2007	FY 2008	FY 2009
Small Combat Vehicle with Robotic Automation	0.000	0.000	2.500	4.000

(U) The Small Combat Vehicle with Robotic Automation program will evaluate and design small, survivable, highly mobile ground combat vehicles that have combat firepower equivalent to today's larger ground vehicles (e.g. M2/M3 Bradley) but in a highly deployable package of five ton to ten ton with a single crew person/operator on board (with the option for operation with no crew person in an unmanned configuration). Smaller vehicle weights enable effective deployability in helicopters or C-130 aircraft for vertical envelopment. This program seeks to achieve an optimal mix of manned and unmanned technologies in a small, well protected, highly deployable combat vehicle. By utilizing automation technologies in vehicle driving and vehicle payload systems (reconnaissance sensors and weapons), a single crew person in the combat vehicle can effectively drive and operate payloads concurrently at appropriate times while still providing high-level supervisory control over all systems. At mission critical times, the crew person can be removed and supervisory control can be given off-board from a separate controlling vehicle. The key technologies that enable a Small Combat Vehicle with Robotic Operation include sensor-based autonomous & semi-autonomous navigation,

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

robust indirect driving (via combinations of cameras, perception-generated views of the terrain, or teleoperation), robust supervisory semi-autonomous control and teleoperation to allow vehicle operation from another vehicle, high density low-weight armor, aided target acquisition and targeting-based remote weapons stations, effective but minimalist warfighter-machine interfaces for crew person interaction with semi-automated driving and payload systems, and high performance vehicle mobility systems (suspensions and drivetrains).

- (U) Program Plans:
- Conduct initial studies and develop vehicle automation concepts.
  - Conduct experiments and evaluations of candidate technologies.
  - Initiate preliminary designs.

	FY 2006	FY 2007	FY 2008	FY 2009
Army Hypersonics Advanced Technology	0.000	2.000	0.000	0.000

- (U) Establish Hypersonics Advanced Technology initiatives.

	FY 2006	FY 2007	FY 2008	FY 2009
Extreme Light Sources for Defense Applications	0.000	1.440	0.000	0.000

- (U) Research extreme light sources.

	FY 2006	FY 2007	FY 2008	FY 2009
Optical Sensor System	0.000	1.000	0.000	0.000

- (U) Research optical sensors.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-04	

	FY 2006	FY 2007	FY 2008	FY 2009
Research on a molecular approach to HazMat Decontamination	0.000	1.000	0.000	0.000

(U) Research on a molecular approach to HazMat Decontamination.

	FY 2006	FY 2007	FY 2008	FY 2009
RF Counter Sniper	1.000	0.000	0.000	0.000

(U) The RF Counter Sniper program evaluated enabling technologies and system capabilities required to recognize the RF signature of a weapon (rifle, RPG etc.) pointed towards the system in an urban environment, before it is fired. The enabling technologies evaluated were survivability, autonomous operations and command and control.

(U) Program Plans:

- Configured radar and developed algorithms.
- Collected static data, and analyzed radar effectiveness and sensitivity, and developed system CONOPS/trade analysis.
- Collected representative data in a Military Operations in Urban Terrain (MOUT) environment to do final trade analysis and to determine system performance parameters.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

R-1 Line Item No. 16

Page 29 of 74

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**  
R-1 Line Item No. 16  
Page 30 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Advanced Tactical Technology TT-06	111.199	111.706	127.550	136.351	145.256	145.256	145.256	145.256

**(U) Mission Description:**

(U) This project focuses on four broad technology areas: (a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, holographic laser sensors, communications, and high-power laser applications; (b) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; (c) enabling technologies for advanced aerospace systems and emerging payload delivery concepts; and (d) new approaches for training and mission rehearsal in the tactical/urban environment. Additionally, this project will develop new tactical systems for enhanced air vehicle survivability, precision optics, electronic warfare, and advanced air breathing weapons.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
High Power Fiber Lasers	12.606	6.700	6.242	6.000

(U) The High Power Fiber Lasers program will develop and demonstrate single mode, single polarization fiber lasers with output powers greater than one kilowatt from a single aperture. Tens of kilowatts output power and capability to scale to greater than hundreds of kilowatts output power and beyond will be demonstrated through coherent combining of the output power from multiple fiber lasers. High power fiber lasers will provide a quantum leap in defense capabilities by simplifying the logistic train and providing a deep magazine, limited only by electric power, in a compact footprint. For theater/area defense and self-protection of combat platforms, they will provide speed of light engagement and flexible response against cruise missiles, reconnaissance unmanned air vehicles (UAVs), and rockets.

(U) This program will also develop single mode single polarization helical-core fiber lasers. Helical-core fiber lasers overcome the limitations of conventional linear core fibers for bend radius to filter higher order modes at multi-kilowatt output powers. The pitch and offset of helical-core fibers and doping and index profile in the gain region will be optimized for single mode output power.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

- (U) Program Plans:
- Demonstrated greater than 100-watt single mode polarized output power from a single large mode-field area fiber.
  - Demonstrate greater than 1 kilowatt single mode single polarization output power from a single large mode-field area fiber.
  - Demonstrate 10 kilowatt single mode, single polarization output power from a helical-core fiber laser.
  - Demonstrate capability to coherently combine the output of multi-kilowatt fiber lasers and scale to greater than hundreds of kilowatts output power.

	FY 2006	FY 2007	FY 2008	FY 2009
High Powered FemtoSecond Laser Diodes	5.000	4.000	4.000	2.000

(U) The development of high power, reliable semiconductor laser diodes with tunable femtosecond pulse widths and highly scalable power levels, represents a technological advance of great potential utility to the Department of Defense. The successful demonstration of a compact, efficient, and powerful laser diode system could lead to incredible advances in micromachining, communications, ultra-short pulse spectroscopy, light detection and ranging (lidar), and directed energy applications.

- (U) Program Plans:
- Model and evaluate concepts for ultra-short pulse, high irradiance laser diodes and select mode locked grating coupled surface emitting laser diodes (GCSEL) and semiconductor optical amplification using chirped pulse amplification and compression.
  - Develop a series of GCSEL-based ultra-short pulse, ultra-high power lasers culminating in a 1 milliJoule/200 femtosecond per pulse laser system with a 10 kHz repetition rate that can fit into a shoebox. This represents a seven order of magnitude jump in the performance of semiconducting laser diodes.
  - Demonstrate the ability of femtosecond laser to micromachine complex Defense parts.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

	FY 2006	FY 2007	FY 2008	FY 2009
Super High Efficiency Diode Sources (SHEDS)	4.493	4.000	6.000	5.000

(U) The goal of the SHEDS program is to develop laser diodes that are 80% efficient in converting electrical power to optical power. These will be used for supplying the optical power to ytterbium (Yb) and neodymium (Nd) solid state lasers operating near 1060 nanometers (nm). Such high efficiency laser pumps for these solid state lasers will lead to dramatic reductions in the size and weight of 100kW class diode pumped solid state lasers.

(U) Program Plans:

- Achieve 80% efficiency from single diode bars.
- Achieve a spectral range of 880nm to 980nm, the range for pumping directly into the upper laser level of Nd and Yb.
- Provide wavelength stabilization to prevent thermal drift of the diode bar wavelength outside of the range of high absorption of the laser transition.
- Achieve a power level of 480W/cm<sup>2</sup> per diode stack operating continuously.
- Achieve a peak power of 2000W/cm<sup>2</sup> for operating the stacks in a quasi-continuous wave (CW) mode with a duty cycle of no less than 25%.
- Achieve much more efficient diode stacks that will reduce the waste heat to one third of that generated by currently available diode bars.

	FY 2006	FY 2007	FY 2008	FY 2009
High Energy Liquid Laser Area Defense System (HELLADS)	21.500	25.000	35.250	35.250

(U) The goal of the High Energy Liquid Laser Area Defense System (HELLADS) program is to develop a high-energy laser weapon system (~150 kW) with an order of magnitude reduction in weight compared to existing laser systems. With a weight goal of less than 5 kg/kW, HELLADS will enable high-energy lasers (HELs) to be integrated onto tactical aircraft and will significantly increase engagement ranges

**UNCLASSIFIED**

R-1 Line Item No. 16

Page 33 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

compared to ground-based systems. The HELLADS program is also funding a novel turbulence control effort, the Aero Adaptive Beam Control program, in order to optimize aft laser operations in flight.

(U) The HELLADS program has completed the design and demonstration of a revolutionary subscale high energy laser that supports the goal of a lightweight and compact high energy laser weapon system. An objective unit cell laser module with integrated power and thermal management is being designed and will be fabricated and demonstrated at an output power of 17 kW. Based on the results of this demonstration, additional laser modules will be fabricated to produce a 150 kW laser that will be demonstrated in a laboratory environment. The 150 kW laser will then be integrated with an existing beam control capability to produce a laser weapon system demonstrator. The capability to shoot down tactical targets such as surface-to-air missiles and rockets will be demonstrated.

(U) The goal of the Aero Adaptive Beam Control (ABC) program is to improve the performance of high energy lasers on tactical aircraft against targets in the aft field of regard. In order to achieve high off-boresight targeting capability, current optical turret designs protrude into the flow. This causes severe aero-optic distortions in the aft field of regard due to turbulence in the wake and the unsteady shock movement over the aperture. These distortions decrease the power flux on target (the measure of lethality for a directed energy system) and limit the directed energy system to targets in the forward field of regard. This program will optimize flow control strategies for pointing angles in the aft field of regard. The program will also explore the ability of the flow control system to be synchronized with the adaptive optics. This effort will initially focus on wind tunnel testing to prove the feasibility of steady and periodic flow control techniques to reduce or regularize the large scale turbulent structures surrounding an optical turret. These tests will culminate in a hardware-in-the-loop demonstration with an adaptive optics system. Following successful wind tunnel demonstrations, a preliminary design of a flight test turret incorporating flow control on the turret and compatible with the HELLADS laser system will be undertaken. Flight test of the selected flow control system will be conducted, simulating an operational system in a representative environment.

- (U) Program Plans:
- HELLADS
    - Develop and test a 17 kW objective system laser module with integrated power and thermal management subsystems.
    - Complete preliminary design of a 150 kW laser weapon system.
    - Complete detailed design and fabricate a 150 kW laser weapon system demonstrator.
    - Demonstrate performance of a 150 kW HEL and of a 150 kW laser weapon system.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

- Aero Adaptive Beam Control
  - Conduct design trade studies to develop preferred flow control approach.
  - Develop wind tunnel test plan and design wind tunnel model.
  - Conduct preliminary tests of flow control approaches using computational fluid dynamics and small scale wind tunnel tests.
  - Conduct full scale wind tunnel test to measure aero-optics distortions for turret.
  - Utilize flow control to reduce aero-optics effects and measure wavefronts to model effects of adaptive optics processing.
  - Integrate adaptive aero optics system with wind tunnel model to conduct hardware-in-the-loop wind tunnel demonstration.
  - Design flight test hardware and develop flight test plan.
  - Build turret incorporating flow control and compatible with HELLADS laser system and flight test measuring beam quality improvement in flight.

	FY 2006	FY 2007	FY 2008	FY 2009
High Performance Algorithm Development	13.371	14.000	14.500	16.000

(U) The programs in this area identify, develop and demonstrate new mathematical paradigms enabling maximum performance at minimum cost in a variety of DoD systems applications. They will look for opportunities to aggressively leverage the power of mathematical representations in order to effectively exploit the power of large-scale computational resources as they apply to specific problems of interest. They also cultivate theoretical breakthroughs in areas of basic mathematics having relevance to emerging Defense sciences and technologies. The products are typically advanced algorithms and design methodologies. DARPA is pursuing the development of well-conditioned fast algorithms and strategies for the exploitation of high-dimensional data (i.e., data with a high number of degrees of freedom) in order to deal with a variety of complex military problems including digital representation and analysis of terrain and other geospatial data, efficient high fidelity scattering computations of radar scattering for predictive design and exploitation of radar cross sections, and efficient automatic mapping and optimization of signal processing kernels onto advanced Departmental computational hardware architectures.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

(U) Program Plans:

- Demonstrate efficient, accurate, predictive algorithms for electromagnetic scattering from objects composed of inhomogeneous and anisotropic materials and including cracks, cavities, gaps, and thin edges; apply these codes to the accurate computation of radar cross section (RCS).
- Demonstrate efficient scattering codes capable of accurate computation of RCS for cruise-missile-sized vehicles with realistic material boundary conditions and full complexity components including high fidelity computational electromagnetic modeling capability for multisensor apertures and arrays.
- Produce high-level algorithm-specification tools that will allow application domain experts (e.g., engineers in signal processing or fluid dynamics) to specify algorithmic Digital Signal Processing (DSP) library modules equal to expertly hand-tuned modules in one tenth the speed and power.
- Design and implement unified digital representations for map, terrain, and other geospatial data that will support highly efficient storage, query, and registration of geographical information from disparate sources.
- Demonstrate localized representations for high-altitude gravity data that provide the precision of current representations with ten percent of current storage requirements.
- Develop and test algorithms to exploit the presence of multiple scattering and clutter (e.g., foliage canopy) to enable imaging in the presence of multiple scattering and dispersion to enable image formation for acoustic, synthetic aperture radar, and active electro-optic sensors. Exploit multiple scattering and clutter to enable increased communication bandwidth at fixed power in acoustic and wireless applications.
- Create new system-level algorithms that are able to design and guarantee performance of complex systems while managing the uncertainty that is inherent in large, multiscale, highly interconnected systems where dynamics are important.
- Develop the required theoretical advances to establish rigorous foundations and methods in order to exploit recent discoveries of the presence of very low-dimensional intrinsic structure in large data sets of extrinsically high dimension.
- Develop techniques for self assembly of dynamic, non-brittle, heterogeneous networks of surveillance and communications assets based upon mathematical inverse methods.
- Develop algorithms for accurate navigation in densely built urban areas based on image matching.

UNCLASSIFIED

R-1 Line Item No. 16

Page 36 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

	FY 2006	FY 2007	FY 2008	FY 2009
Integrated Sensing and Processing	5.000	6.500	8.043	12.000

(U) The Integrated Sensing and Processing program will open a new paradigm for application of mathematics to the design and operation of sensor/exploitation systems and networks of such systems by developing and applying novel optimization methodologies for integrating sensing, processing, and information exploitation functionality in sensor systems. This program will create tools enabling the design and global optimization of advanced sensor system architectures comprising fully interdependent networks of functional elements, each of which can fill the roles and functions of several distinct subsystems in current generation sensor systems. Payoffs will include improved performance with reduced complexity of hardware and software in a wide variety of systems, including agile adaptive arrays for missile seekers, unmanned air vehicles, and space-borne sensors; novel waveforms, adaptive waveform design and processing for object identification in dispersive and turbulent media; and novel approaches to multiplexed hyperspectral chemical/biochemical sensing systems.

(U) Program Plans:

- Develop and demonstrate new mathematical approaches to adaptive optimal control of tunable, mode-switchable, and configurable sensor systems/networks in which detection, estimation, classification, and tracking requirements determine sensing system operating parameters.
- Investigate extraction of high-level information directly from analog signals as part of the analog-to-digital conversion process, allowing joint optimization of traditionally separate sensing and processing functions.
- Develop real-time waveform design and scheduling strategies for ambiguity reduction and clutter mitigation in pulse diversity radar systems.
- Demonstrate feasibility of designs for quadrature thinning of two-dimensional conformal arrays that exhibit the same or better beam patterns than conventional arrays using fewer transmit/receive modules.
- Create new methods for processing sensor data and the design of sensors in which only non-redundant data is sampled to reduce sensor complexity, computational time and power consumption thereby dramatically improving sensor response.
- Develop information-theoretic metrics relating detection, estimation, classification, and tracking requirements to waveform structure in active sensing systems and use these metrics to devise new classes of mathematically optimal waveforms.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

	FY 2006	FY 2007	FY 2008	FY 2009
Training Superiority	20.950	24.271	28.000	35.000

(U) The Training Superiority program will change the paradigm for the way the military trains by creating new approaches to increase technical and physical competence as a result of revolutionary new training techniques developed in this program. Passive teaching approaches, including web-based training, will not succeed in instilling the skills and knowledge needed in the new land-battlefield, with higher demands on fewer soldiers, including the need to control and interact with highly technical unmanned systems. These new training approaches will include elements of human-tutor interactions and the emotional involvement of computer games coupled with the fidelity and feedback of Combat Training Center learning. In addition, these new training approaches will be linked into existing Service and Joint training systems to form a self-sustaining architecture, allowing continuous on-demand training anywhere at anytime.

(U) Program Plans:

- Develop, demonstrate and validate a continuously available, on-demand combat training system for all forces in the skills, especially those required in the urban environment, that are needed for successful performance across a comprehensive range of military operations, engagements and come-as-you-are wars.
- Develop, validate, demonstrate and deliver to military last-meter training systems that are focused on specific areas of performance requirements (e.g., “seabag sized” air mission trainer, tactical language instruction, and convoy protection).
- Create an overarching training architecture populated with scalable multiple last-meter training systems that will allow any unit or individual, active, reserve, or civilian, to enter the virtual training world at any time, from any place, using existing hardware, and receive training tailored to specific individual training needs. Develop approaches to automatically insert lessons learned and incorporate realistic simulation of populations into that architecture.
- Exploit automated semantic analysis and multiplayer games to dramatically improve the training of teams and provide real-time feedback on team performance.
- Exploit the use of multiplayer games to rapidly (weeks, not years) teach practical language and gestures to enhance interactions between soldiers and civilian populations. Investigate their use for improving the prediction of consequences of military activity.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

- Develop and demonstrate the use of computer simulations that can be updated with real world data in hours to allow truly realistic instant rehearsal of military operations to dramatically improve the planning and execution of those operations.
- Exploit technologies developed in massively multi-player online games to create a training environment to detect, recognize, conceptualize, represent and experiment with the problems faced meeting Stability, Security, Transition and Reconstruction (SSTR) objectives, as well as formulate common solutions to these problems within the context of an advanced gaming, simulation, and instrumented environment.
- Develop a biological/physiologically based mathematical foundation for the predictions of the behavior at the individual, small group level and export into training scenarios.
- Leverage the DoD's world class warfare simulations (having validated models and doctrinally correct behaviors) in a persistent Massively Multi-player Game (MMG)-type environment that incorporates a variety of existing technologies including commercial game products, high-performance computers, and agent technologies.

	FY 2006	FY 2007	FY 2008	FY 2009
Air Laser	3.344	3.995	4.400	3.400

(U) The Air Laser program will investigate the potential for a high energy laser (HEL) concept based on direct diode pumping of liquid oxygen. If successful, the Air Laser could provide a safe, efficient kilowatt-to-megawatt-class HEL which combines the advantages of chemical and solid state lasers and minimizes the disadvantages: it operates in the eye-safe wavelength regime; it uses liquid oxygen as the gain medium and as the diode array coolant, resulting in the reduction or elimination of a separate thermal control system; it uses efficient, high power diode pump sources resulting in a compact device much smaller than either chemical or solid state lasers; and its pulse length is variable from continuous to sub-picosecond, allowing flexibility in weapons effects.

- (U) Program Plans:
- Performed system/utility analyses.
  - Develop and demonstrate a 1 kW output power laser design.
  - Develop and demonstrate 20 kW laser design.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

- Develop 100 kW-to-megawatt laser design.
- Develop kilowatt-class red diode stacks.
- Develop high-power mirror coatings for this wavelength.

	FY 2006	FY 2007	FY 2008	FY 2009
Efficient Mid-Wave Infrared Lasers (EMIL)	0.000	2.000	3.000	4.001

(U) The Efficient Mid-Wave Infrared Lasers (EMIL) program will develop efficient solid-state coherent sources to cover the atmospheric transmission bands in the mid-wave infrared (MWIR; 3-5 μm). Infrared countermeasure (IRCM) systems in particular depend on intense sources at these bands. The current generation IRCM systems utilize diode-pumped Tm lasers used to pump optical parametric oscillators (OPO), most commonly based on zinc germanium phosphide (ZGP).

(U) The lasers developed in this program will operate across the three relevant bands within the MWIR at 10W power with wall plug efficiencies of at least ten percent. By virtue of the enormous volumetric reduction (100-1000X), power reduction (10X), and superior pulse format (cw-operation), such sources will enable new architectures and approaches permitting IRCM systems to be deployed on platforms (e.g., rotocraft) which are highly vulnerable to Man Portable Air Defense Systems (MANPADS) and other threats but for which current IRCM systems are prohibitive or are inadequate (e.g., unable to defeat staring sensors). At least two diode-based laser approaches will be explored in this program, both involving antimonide-based compound semiconductor (ABCS) materials. These include intersubband-based quantum cascade lasers (QCLs) and type-II antimonide lasers, including so-called “W-configuration” approaches, the name taken from the shape of the conduction band profile.

(U) Program Plans:

- Complete design and deposition of complex multi-layered structures incorporating antimonides.
- Reduce internal losses across the large number of layers.
- Achieve the 10-W total output power by combining power of multiple devices.
- Overcome the parasitic mechanisms such as Auger recombination to reduce lasing threshold and achieve high temperature operation.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

	FY 2006	FY 2007	FY 2008	FY 2009
Sonic Projector	0.000	2.500	4.000	3.000

(U) The goal of the Sonic Projector program is to provide Special Forces with a method of surreptitious audio communication at distances over 1 km. Sonic Projector technology is based on the non-linear interaction of sound in air translating an ultrasonic signal into audible sound. The Sonic Projector will be designed to be a man-deployable system, using high power acoustic transducer technology and signal processing algorithms which result in no, or unintelligible, sound everywhere but at the intended target. The Sonic Projector system could be used to conceal communications for special operations forces and hostage rescue missions, and to disrupt enemy activities.

- (U) Program Plans:
- Complete initial feasibility studies.
  - Create concept of operations and conduct military utility analyses.
  - Develop and demonstrate initial prototype.

	FY 2006	FY 2007	FY 2008	FY 2009
Revolution in Fiber Lasers (RIFL)	0.000	0.000	2.500	4.000

(U) The goal of the Revolution in Fiber Lasers (RIFL) program is to develop multi-kilowatt, single-mode, narrow linewidth fiber laser amplifiers using diffraction-limited diode pump arrays to achieve the requisite power and coherence for future multi-kilowatt directed energy architectures. The excellent beam quality of the diffraction-limited diodes allows for a tenfold reduction in cladding diameter. The faster, more efficient coupling from cladding to core will result in a 10x shortening of the required fiber length to avoid nonlinearities and create narrow linewidth beams. Furthermore, the reduction in cladding diameter will provide a 70x increase in the heat removal rate from the core, increasing the thermal fiber laser power scaling limit to 10kW. This program will construct stable 100 W, 10-emitter bars (10W/emitter) and assemble a 15-bar fiber tree capable of producing 1.5 kW of diffraction-limited diode laser pump power per module. These modules will then be used to pump a multi-kilowatt fiber laser amplifier.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

- (U) Program Plans:
- Achieve narrow linewidth (<60 MHz), single mode, kilowatt-scale fiber lasers.
  - Develop and utilize diffraction-limited laser diode pumps to reduce cladding diameter and length of the fiber laser.

	FY 2006	FY 2007	FY 2008	FY 2009
Coherently Combined High-Power Single-Mode Emitters (COCHISE)	0.000	0.000	3.200	4.200

(U) The objective of the Coherently Combined High-Power Single-Mode Emitters (COCHISE) program is to develop four new, breakthrough technologies that will result in improved diode bar lifetime and beam quality. Ultimately, these technologies will also lead to coherent combination of individual emitters in laser diode bars and arrays. Coherent combination of laser diode arrays would provide high power laser architectures that are up to three times more efficient than existing diode-pumped solid-state laser technology, while improving beam quality and increasing far-field, on-axis intensity.

- (U) Program Plans:
- Develop fault mode protection at the laser diode bar level.
  - Design new electrical and optical diode bar prescreening technologies.
  - Develop 100-watt laser diode bars with > 1-watt, single-mode emitters.
  - Design methods for coherently combining high power, single-mode laser diode emitters.

	FY 2006	FY 2007	FY 2008	FY 2009
Laser Enhanced Sighting System (LESS)	0.000	0.000	3.437	6.500

(U) The objective of the Laser Enhanced Sighting System (LESS) program is to design a novel weapon-mounted sighting system that combines optical, night, and thermal sights into a single unit. At present, three different sights are required by the war fighter under various environmental conditions. This results in high costs (over \$10K cumulatively) and undue logistics. In addition, presently available night and

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

thermal sights are power hungry, which limits their usage, while sighting range and resolution are limited without target illumination and ranging capability. These limitations combine to compromise the warfighter's ability and efficiency to execute missions. The LESS sighting system would weigh approximately one-tenth that of currently available sighting equipment, and greatly extend the duration per charge. The program would provide additional military utility by enabling the warfighter to see targets under all weather and battlefield obscuration conditions, such as illumination under starlight, while enabling ranging to target capability. This program will leverage recent breakthroughs in achieving broad spectral response using MEMS tuning membrane overlaid on an indium-antimony (InSb) or mercury-cadmium-tellurium (HgCdTe) detector/focal plane array.

(U) Program Plans:

- Develop MEMS/InSb or HgCdTe responsivity versus wavelength model as a function MEMS gap to validate if the responsivity of the combined system could be improved by a factor of 10x.
- Develop MEMS tunable membrane on InSb or HgCdTe substrates and measure performance with wavelength at known voltages and temperature.
- Design and build electronics board sufficient to record images at various wavelengths with and without MEMS membrane.

	FY 2006	FY 2007	FY 2008	FY 2009
Architecture for Diode High Energy Laser Systems	8.237	8.000	4.978	0.000

(U) This program will develop all-solid-state laser diode drivers with integrated fault mode protection that will decrease the size and weight of these laser systems by a factor of 4 (by allowing the laser diode array to operate at elevated temperature), increase the diode array lifetime tenfold, and decrease lifecycle costs fivefold. These improvements will be attained for diode laser arrays operating in the IR, visible and ultra-violet regions of the spectrum. By allowing operation at higher temperatures, these new drivers will allow broader tuning of the laser light which is crucial to the detection of both chemical and biological agents with high signal-to-noise and low probability-of-false-alarm. These new diode laser drivers will utilize feedback control systems which detect electrical and optical filamentation within the laser diode and laser diode bars, and then interrupt power to the laser diode system before thermal instabilities can lead to accelerated diode aging and premature diode failure.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06	

- (U) Program Plans:
- Demonstrate a three-fold improvement in diode array lifetime with a preliminary data set that projects to tenfold improvements in diode lifetime.
  - Integrate fault mode protection for stable operation of the laser diode array at elevated temperatures which leads to a fourfold reduction in the size and weight of the thermal cooling and heat exchanger systems which currently dominate laser size and weight.
  - Combine new technologies being developed in industry and universities/government laboratories to provide the ultra-compact, tunable, solid-state lasers required for remote detection and destruction of both chemical and biological agents.

	FY 2006	FY 2007	FY 2008	FY 2009
Laser Star	4.900	2.000	0.000	0.000

(U) The Laser Star program is investigating technologies and techniques for reducing the effect of atmospheric turbulence and other effects on the quality and clarity of images obtained by ground based telescopes. Current technology uses natural stars or an artificial star (called a "guide star") to provide a reference image from which the effects of the atmosphere can be computed and cancelled. Natural stars limit the pointing of the telescope. Artificial guide star technology currently makes use of either stratospheric Rayleigh backscatter or mesospheric sodium resonance scattering. These techniques have been utilized to successfully demonstrate strategies for wavefront compensation, but suffer from practical restrictions limiting operational utility. Rayleigh guide stars can be effectively generated to altitudes of 15 – 20 km, beyond which decreasing air densities reduce the backscatter to the point where unrealistic laser powers are required for useful return signal. The altitude is insufficient to provide full atmospheric sampling and suffers from sensor/target signal cancellation. Sodium resonance scattering is available to 90 km, which is an essentially complete atmosphere sample, but the return is monochromatic and cannot provide information about turbulence-induced absolute tilt. Laser Star is exploring approaches to overcome these shortfalls including advanced multi-conjugate adaptive optics as well as nonlinear techniques.

- (U) Program Plans:
- Completed concept design.
  - Developed experiment design and procured long lead items.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

- Conduct experiment and analyze results for integration with atmospheric compensation programs.

	FY 2006	FY 2007	FY 2008	FY 2009
Coherent Communications, Imaging and Targeting	6.200	5.000	0.000	0.000

(U) The Coherent Communications, Imaging and Targeting (CCIT) program is developing new capabilities for secure communication up-links, and aberration free 3-dimensional imaging and targeting at very long ranges. Innovative design concepts for MEMs based Spatial Light Modulators (SLMs), and system integration of photonics and high-speed electronics are also being explored.

- (U) Program Plans:
- Complete 64 x 64 device with individually “wired” test pixels.

	FY 2006	FY 2007	FY 2008	FY 2009
Rapid Checkpoint Screening	5.466	3.740	0.000	0.000

(U) The Rapid Checkpoint Screening program will develop and demonstrate techniques and sensors to detect life-threatening deceptions in military controlled portals such as military checkpoints that are compatible with existing portal screen approaches.

- (U) Program Plans:
- Identify physiological signals that correlate with deception including laser vibrometry, lidars, multi-spectral eye tracking, and short range electrical potential.
  - Validate the measurement process.
  - Establish new concepts for understanding deception processes on a scientific basis.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-06	

	FY 2006	FY 2007	FY 2008	FY 2009
Language and Speech Exploitation of Resources Advanced Concept Technology Demo	0.132	0.000	0.000	0.000

(U) DARPA’s Compact Aids for Speech Translation (CAST) program developed speech translation technologies using handheld devices for military field operations. The Language and Speech Exploitation of Resources Advanced Concept Technology Demonstration (ACTD) program transitioned the CAST technology into the ACTD to support military utility assessments (MUAs). The application of information extraction techniques to speech translation has significantly advanced technology. This new technology will allow flexible and accurate translation of varying utterances without requiring recognition and translation of every word in the utterance.

(U) Program Plans:

- Installed a translator on small, readily available platforms (e.g., laptops, handhelds).
- Tested and evaluated language technology in the service labs.
- Transitioned the translator technology to the ACTD for MUAs.
- Tested and evaluated technology in operational context; LASER ACTD effort complete.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>						DATE February 2007		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Aeronautics Technology TT-07	59.179	69.927	76.326	98.576	105.752	105.752	132.174	145.752

**(U) Mission Description:**

(U) Aeronautics Technology efforts will address high payoff opportunities that dramatically reduce costs associated with advanced aeronautical systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. This includes advanced technology studies of revolutionary propulsion and vehicle concepts, sophisticated fabrication methods, and examination of novel materials for aeronautic system applications.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Micro Adaptive Flow Control (MAFC)	4.106	4.619	0.000	0.000

(U) Micro Adaptive Flow Control (MAFC) technologies enable control of large-scale aerodynamic flows using small-scale actuators. MAFC technologies combine adaptive control strategies with advanced actuator concepts like micro-scale synthetic jets, microelectromechanical systems (MEMS)-based microactuators, pulsed-blowing, combustion actuators and smart structures to cause the delay, or prevention of fluid flow separation. MAFC technologies have been and will continue to be explored for applications such as download and drag reduction for air vehicles, facilitation of long-range flight with reduced fuel consumption and logistical implications using vortex mitigation, adaptive lift-on-demand for agile missiles and uninhabited tactical aircraft, supersonic boundary layer control, lightweight gas turbine engines, and low-drag, non-intrusive methods to aerodynamically steer projectiles for extended range and precision.

**(U) Program Plans:**

- Completed sled design and fabrication for High Frequency Excitation for Supersonic Weapons Release (HIFEX) phase III test.
- Completed HIFEX system design and fabrication for HIFEX phase III test.
- Designed and integrated SCORPION full-scale control system.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

- Completed 1- Mach 2.0 HIFEX system sled test.
- Complete SCORPION system design and fabrication for SCORPION phase III test.
- Configure and execute Phase III full-scale technology demonstrations.

	FY 2006	FY 2007	FY 2008	FY 2009
Miniature Propulsion Concepts	7.340	5.334	6.706	7.500

(U) Small Unmanned Air Vehicle (UAV) payload and endurance capabilities can be expanded by increasing the power density and efficiency of their power plants. This program will develop concepts for small scale class propulsion systems. Small gas turbine engines are typically very inefficient, below 7%, for engines below 10 horsepower. This program will develop gas turbine engines under 10 horsepower with a power density greater than 2HP/pound and a thermal efficiency greater than 25%. In addition, novel concepts for developing micro UAV's that emulate and/or borrow propulsion approaches from birds will be developed. These will provide a unique Intelligence, Surveillance, and Reconnaissance (ISR) capability for the dismounted soldier.

(U) Program Plans:

- Demonstrate small, long endurance engine using novel designs for un-cooled ceramic components with power density greater than 2 HP/lb, efficiency greater than 25% and a durability of greater than 500 hours.
- Demonstrate a multifunctional wing structure plus battery for micro air vehicles (MAV) that yields three times more duration than a traditional wing structure and conventional battery.
- Investigate compatibility of optical flow and uncooled IR approaches with multifunctional structures to enhance surveillance capability.
- Transition micro air vehicles to military applications.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

	FY 2006	FY 2007	FY 2008	FY 2009
Peregrine Counter UAV	1.219	5.146	6.840	3.000

(U) The Peregrine Counter Unmanned Air Vehicle (UAV) program will develop a low-cost capability to counter small UAV threats. Small UAVs with GPS guidance systems have reached such a low cost level that expendable UAVs can be easily obtained from components available to the civilian aircraft and hobby market. Current air defense assets are unable to provide a cost effective response to this threat. The Peregrine program will develop and demonstrate a UAV interceptor aircraft that will utilize a dual propulsive power system to provide very high endurance for loiter and surveillance and a very high dash speed for intercept and kill. The program will also identify operating scenarios and system requirements for both domestic situations and regions of conflict, validate critical technologies, and demonstrate a suitable system design and concept of operations.

- (U) Program Plans:
- Defined system requirements.
  - Develop concept design.
  - Demonstrate feasibility of threat detection and airspace integration.
  - Demonstrate aircraft performance and kill capability.

	FY 2006	FY 2007	FY 2008	FY 2009
High Speed / Hypersonic Reusable Demonstration	30.000	20.700	0.000	0.000

(U) This program is a joint DARPA/Air Force initiative that is designing, developing, and demonstrating combined cycle engine components for a reusable hypersonic cruiser in conjunction with the Falcon program (PE 0603287E, Project SPC-01). Ultimately, the studies and developments under this program may result in the first controllable, recoverable, and reusable hypersonic system demonstration. Initial designs will allow for either a manned or unmanned version, and provide viable options for long-range strike and affordable access to space. The program is divided into two efforts—the High Speed Turbine Engine Demonstration (HiSTED) and the Scramjet Engine Demonstration (SED).

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

(U) The HiSTED objectives are to design, fabricate, and ground test a high Mach expendable turbine engine capable of Mach 3-4+ operation. The objective of the ground demonstration is to verify, via simulated altitude testing, that engine performance and operability characteristics at key transonic and maximum Mach/altitude cruise flight conditions meet anticipated system application needs. Successful completion of the Phase I ground demonstration will enable Phase II development of a reusable turbine-based combined cycle engine capable of accelerating a hypersonic cruise vehicle to Mach 4+.

(U) The SED effort seeks to design, fabricate, and fly a hypersonic vehicle powered by the HyTech scramjet engine over a broad range of Mach numbers. The SED flight vehicle will be boosted to Mach 4.5 where the scramjet engine will be started and the vehicle will accelerate to Mach 6.5 to Mach 7+. This will demonstrate a scramjet engine that produces thrust greater than vehicle drag, accelerating a free flight vehicle over a range of Mach numbers. This will be the first-ever demonstration of a flight-weight, fuel-cooled scramjet-powered vehicle. It will also establish the viability of the scramjet engine for integration with high speed turbines such as that developed under HiSTED and/or rocket engines to create combined cycle engines for hypersonic cruise vehicles and affordable on-demand access to space systems.

- (U) Program Plans:
- HiSTED
    - Conducted Critical Design Reviews of two engine concepts.
    - Complete high temperature turbine components design and fabrication.
    - Assess supercritical fuels.
    - Assess high temperature lubrications and bearings.
    - Perform component integration.
    - Conduct integrated engine ground testing.
  - SED
    - Developed the flight vehicle design.
    - Conducted freejet engine testing.
    - Fabricate flight demo vehicle.
    - Conduct flight testing.

UNCLASSIFIED

R-1 Line Item No. 16

Page 50 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

	FY 2006	FY 2007	FY 2008	FY 2009
Helicopter Quieting	5.020	8.872	10.900	10.800

(U) Studies and analysis of military helicopter operations have shown that the survivability and lethality of U.S. helicopters can be increased by reducing their acoustic signature, which will make them more difficult to detect, track, and engage. The Helicopter Quieting Program is developing revolutionary new rotorcraft design tools that will enable the creation of novel rotor systems that can dramatically reduce the acoustic signature of a helicopter without sacrificing flight performance.

(U) Current rotor development is very costly, involving a time-consuming iterative, trial and error cycle of analysis and model wind tunnel tests, or occasionally, a faster but much riskier analysis path directly to full-scale wind tunnel/flight test. This program will leverage recent advances in computational fluid dynamics to develop physics-based predictive design tools that will enable helicopter rotor designers to explore the revolutionary potential of emerging new rotor noise-reducing technologies with a reduction in the cost and cycle time associated with iterative analysis and test. The program will investigate multiple advanced, low-noise rotor concepts for application to fielded military rotorcraft for a significant reduction in low-frequency in-plane signatures. The most promising concepts will be taken to test, culminating in full scale flight experiment of advanced rotors to confirm acoustic signature reduction and evaluate survivability improvement in an operational environment.

(U) Program Plans:

- Develop and validate high-fidelity, physics-based rotor acoustic predictive tools.
- Identify acoustic design criteria for new rotor system designs based on operational scenarios.
- Develop advanced rotor system designs that incorporate reductions in low-frequency, in-plane signatures for increased survivability without significant impact to flight performance.
- Demonstrate acoustic signature reduction and improved effectiveness in system test and experiment.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

	FY 2006	FY 2007	FY 2008	FY 2009
Nano-Flapping Air Vehicles	5.924	6.956	9.250	9.524

(U) The goal of this program is to develop flapping air vehicle technology that results in a bio-inspired flapping air vehicle with less than two inch wingspan and gross takeoff weight of approximately ten grams or less. Operations in the urban terrain require sensors that can navigate in difficult terrain and be inserted without being detected. Small air vehicles capable of navigating interior domains without GPS would enable autonomous prosecution of a number of high risk missions that are currently performed by warfighters. Key enabling technologies include, flapping wing aerodynamics, kinematics and flight dynamics, lightweight aeroelastically tailored wing structures, miniature navigation systems, micro-propulsion systems, small payloads, and the ability to perch like a bird. This effort will also examine novel materials that can be used to develop integrated wing structures, which change composition to achieve multiple expressions. The program would result in the use of vehicles, which could be camouflaged, or blend into the surrounding landscape, enabling in-theater disposal and prevention of mission detection/compromise.

(U) Program Plans:

- Conduct detailed investigations on unsteady aerodynamic physics to understand fundamental aerodynamic issues.
- Conduct studies integrating aeroelastic phenomena to improve flapping performance.
- Conduct survey/studies of novel building materials.
- Design wing geometry and flapping mechanism for future integration into vehicle design.
- Conduct detailed flapping tests to refine the aerodynamic wing-mechanism design.
- Integrate wing design with air vehicle.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

	FY 2006	FY 2007	FY 2008	FY 2009
Flare Aero Structures	2.000	3.631	0.000	0.000

(U) The Flare Aero Structures program explored and developed a new concept for the take off and landing of a fixed wing aircraft. The landing field requirement for a fixed wing aircraft limits use in both confined (e.g. urban) and remote unprepared areas. This program sought to explore unsteady aerodynamics during rapid pitch up or flare landing maneuvers. It is known that very high lift coefficients can be obtained for a short period of time during such a maneuver. The technical challenge was to develop the aero structures, control effectors and control logic that would allow for a practical application of this phenomenon to a fixed wing aircraft to enable landing in a very short distance.

- (U) Program Plans:
- Developed aerodynamic models and control logic.
  - Conduct flight experiments with scaled aircraft.

	FY 2006	FY 2007	FY 2008	FY 2009
Battlefield Helicopter Emulator (BHE) (formerly MACAW)	3.570	6.469	8.750	8.400

(U) The goal of the Battlefield Helicopter Emulator (BHE), formerly the Macaw program, is to develop a helicopter emulator system carried on a small UAV. The system would provide acoustic and thermal (infrared) emulation of a variety of helicopters. BHE could be used for mine clearing/route determination as well as escort missions. The system would draw fire from ground based adversaries, and relay the information back to the operator for off-board location and prosecution. The BHE system would protect Army and SOCOM helicopters from ground fire, small arms, rocket-propelled grenades (RPGs), man-portable air defense systems (MANPADS), and anti-helicopter mines.

- (U) Program Plans:
- Characterize the acoustic and thermal infrared (IR) signatures of common helicopters.
  - Develop concepts to emulate common helicopter acoustic and thermal IR signatures.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

- Select and integrate sensors and UAV platform.
- Conduct field tests to determine system capability and effectiveness against potential threats.

	FY 2006	FY 2007	FY 2008	FY 2009
Distributed Embedded Propulsion	0.000	4.000	7.000	8.000

(U) The Distributed Embedded Propulsion project will explore fully integrated engine/wing designs to take maximum advantage of a fully coupled engine/wing system. This concept will utilize multiple small engines to provide the thrust for the aircraft, and to allow the engines to be more readily integrated with the aircraft structure and the aerodynamics of the wing. It is expected that distribution of propulsive flow over the wing surface will allow circulation control on the wing through both suction and tangential blowing. Circulation control on the wing provided by the embedded distributed propulsion systems would provide unprecedented maximum lift coefficients, with associated reduction in take-off and landing distance. Military transition targets would be short take-off and landing airlift and transport vehicles, benefiting from improvements possible in take-off and landing distance, as well as innovative concepts such as high aspect ratio flying wings. The program will conduct a series of design, sizing and demonstration efforts, culminating in either a wind tunnel or flight test of a circulation control wing using distributed propulsion, and/or a ground or flight test of a distributed embedded propulsion system.

- (U) Program Plans:
- Conduct trade studies on aircraft sizing.
  - Evaluate conceptual designs of distributed embedded propulsion concepts.
  - Determine engine requirements for distributed propulsion system.
  - Initiate design of distributed embedded propulsion experiments.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

	FY 2006	FY 2007	FY 2008	FY 2009
Laminar Flow Flight Demonstration	0.000	3.200	5.500	9.000

(U) The Laminar Flow Flight Demonstration effort will explore the development of an extended laminar flow wing at both subsonic and supersonic operating conditions, with the potential for a drag reduction of up to 25% compared to a typical fully turbulent wing. Crossflow instabilities dominate the transition process for swept wings. Recent advances in theoretical understanding of the crossflow receptivity and transition process have led to innovative, passive control concepts for the crossflow transition process. Test facilities are not available to demonstrate this flight concept in a quiet flow environment at Reynolds numbers and Mach numbers. Flight testing a swept wing laminar flow control concept appears to be the most direct route to validation of this technology, enabling future aircraft designs to adopt passive crossflow control devices as a proven technology.

- (U) Program Plans:
- Conduct feasibility study of high Reynolds number flight test.
  - Initiate design of flight test experiment.
  - Initiate design of laminar flow wing for demonstration.

	FY 2006	FY 2007	FY 2008	FY 2009
Long Endurance Autonomous Powered Powerfoil (LEAPP)	0.000	1.000	3.250	6.500

(U) The goal of the Long Endurance Autonomous Powered Powerfoil (LEAPP) program is to design, develop and integrate the enabling technologies and system capabilities required to demonstrate an extremely short take-off and landing (ESTOL) vehicle with large payload and long endurance characteristics. The enabling technologies are precision guidance, autonomous operations, parafoil aerodynamic performance, and parafoil integration with sensors/antennas. A LEAPP system will provide 48-hours of continuous organic air-support to small ground units or small marine vessels with a 200lb surveillance and communication package. In addition, the LEAPP will have flexibility to be deployed rapidly and will be affordable based on modular system design and construction.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

- (U) Program Plans:
- Develop LEAPP prototype and demonstrate flight performance.
  - Conduct system level tests for specific missions and CONOPS.
  - Demonstrate operational effectiveness for a class of missions.

	FY 2006	FY 2007	FY 2008	FY 2009
Disc-Rotor Compound Helicopter	0.000	0.000	3.000	6.000

(U) The goal of the Disc-Rotor Compound Helicopter program is to design and demonstrate the enabling technologies required to develop a new type of compound helicopter capable of high-efficiency hover, high speed flight, and seamless transition between these flight states. The aircraft will be equipped with a rotating circular wing having blades that can be extended from the disc edge, enabling the aircraft to takeoff and land like a helicopter. Transition from helicopter flight to airplane flight would be achieved by gradually retracting and stowing the blades as the circular wing assumes the task of lifting. An aircraft capable of long range high speed (300-400 kts) and VTOL/hover will provide mobility and responsiveness for troop and cargo insertion, satisfy an ongoing military interest for higher speed VTOL and hover capable vehicles, be survivable and bridge the gap in helicopter escort and insertion missions. The enabling technologies are disc-rotor configuration, circulation control, seamless reversible transition between hover and wing borne flight, and loading/center-of-pressure control. Specific objectives of the Disc-Rotor Compound Helicopter program include: characterization of the flowfield environment created by a disc-rotor, demonstration of disc-rotor configuration, and design and demonstration of prototype vehicle transition dynamics and operational utility.

- (U) Program Plans:
- Develop a conceptual design and technical approach.
  - Identify, develop, and demonstrate the critical enabling technologies required to meet the performance goals.
  - Design an integrated scaled concept demonstrator vehicle that proves the viability of a disc-rotor concept.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

	FY 2006	FY 2007	FY 2008	FY 2009
Integrated Compact Engine Flow Path	0.000	0.000	3.500	7.000

(U) The goal of the Integrated Compact Engine Flow Path program is to develop a structurally integrated, load bearing, and thrust vectoring nozzle. Integration of compact inlets and nozzles that are lightweight and survivable continue to be a challenge. Traditional nozzles are cantilevered off the engine face and the airframe, with an overlap region to account for thermal growth. This approach to nozzle integration results in heavy, high maintenance nozzles and is structurally inefficient. It also poses a significant engine integration challenge and can drive vehicle sizing. A fully integrated nozzle, designed to take airframe loads through the nozzle, and built of a high temperature ceramic, would address the weight and structural integration problems directly. This approach would also be compatible with fluidic thrust vectoring and would result in a more compact, lighter, and more durable nozzle. Indications are that installed weight reductions of over 50% compared to existing state of the art thrust vectoring nozzles are feasible. This program will design, develop, and demonstrate a full scale, fluidic thrust vectoring nozzle in a direct connect engine test.

(U) Program Plans:

- Perform design trade studies to develop a preferred nozzle design as well as a development and demonstration plan.
- Perform materials and small-component testing.
- Develop nozzle preliminary design.
- Perform detailed design, fabrication, and direct-connect engine test.

	FY 2006	FY 2007	FY 2008	FY 2009
Dropout	0.000	0.000	2.000	3.500

(U) The Dropout (Dead Reckoning for UAV Operations in Urban Terrain) program will develop technologies which provide robust GPS aided navigation to UAVs in environments that are currently problematic. Dropout will address the loss of UAVs that result from navigation failure when GPS signals are interrupted. The solution will include three technical approaches which will be evaluated for operational feasibility: an

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

integrated GPS/INS (Internal Navigation System) which uses accelerometers and gyroscopes tightly coupled with GPS to estimate position when GPS signals are absent; independent sensors such as magnetometers and gravimeters to provide independent information on altitude and orientation; and imagery based navigation systems which use the UAV's own cameras as navigation aides. These solutions will be particularly valuable in urban terrain and will be applicable to future UAVs.

- (U) Program Plans:
- Conduct requirements and interface study.
  - Select teams for navigation system development.
  - Develop systems and test on UAVs.
  - Assist in transition to Services.

	FY 2006	FY 2007	FY 2008	FY 2009
Accelerator	0.000	0.000	3.000	5.300

(U) Accelerator is a technology program to develop accelerator propulsion systems suitable for a variety of high-speed missile and/or vehicle concepts that require substantial off-design thrust from initiation through SCRAMJET-ignition in the flight trajectory. Accelerator will solicit and mature innovations that allow off-the-shelf military turbojet engines to meet the demands of the hypersonic ignition trajectories. Integration technologies unique to high-speed vehicles will also be addressed including variable inlets and nozzle geometries.

- (U) Program Plans:
- Evaluate engine performance enhancers such as mass injection and pre-compression cooling (MIPCC).
  - Conceptual design to establish required engine performance.
  - Closed loop accelerator technology testing in ground facility to simulate design trajectory.
  - Free-jet testing of accelerator system including engine and exhaust nozzles as system.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

	FY 2006	FY 2007	FY 2008	FY 2009
Active Rotor	0.000	0.000	3.380	6.852

(U) The goal of the Active Rotor program is to develop and demonstrate enabling technologies that greatly enhance rotor control and performance to enable a 25-50% improvement in endurance, range, and payload of existing helicopters. Enabling technologies include a dynamically controlled rotor, lightweight high-bandwidth compliant actuators, and integrated vehicle flight control technologies. Over the past several decades, improvements in helicopter rotor performance have not kept pace with the increasing demands of the warfighter. This is apparent today in the high altitude environment of Afghanistan, where troop and materiel transport missions that are normally performed by the UH-60 Black Hawk are being performed by the much larger CH-47 Chinook due to the loss of performance in high/hot conditions. The Active Rotor program will mature the technologies to enable military aircraft such as the Black Hawk to operate effectively in this environment. The Active Rotor program will focus on upgrade of the current UH-60/SH-60/MH-60 Black Hawk/Sea Hawk rotor blades and will demonstrate technologies with broad applicability to military and commercial helicopters.

(U) Program Plans:

- Conduct component technology demonstrations and initiate preliminary design of the Active Rotor System.
- Perform full scale wind tunnel test of the Active Rotor System.
- Conduct flight test of the Active Rotor System.

	FY 2006	FY 2007	FY 2008	FY 2009
Lightweight High Efficiency Aircraft Power Generation	0.000	0.000	3.250	7.200

(U) The goal of the Lightweight High Efficiency Aircraft Power Generation program is to develop a lightweight, fuel-efficient system to deliver up to 2 megawatts (MWs) of electrical power to support the integration of high energy laser weapons on airborne platforms. Conventional power generating systems of this scale are large and heavy, respond too slowly to power demands from the laser system, are not fuel efficient, and impose a significant performance penalty on the host aircraft. The program will develop and demonstrate at least one novel power generation

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-07	

approach that is capable of providing full power (2 MW at 40,000ft/0.8Mach) within 0.1-2.0 seconds and that can operate in a fuel-efficient standby mode. The power generation system will be tailored for integration on existing bomber and transport aircraft with minimal integration penalties and will support both high energy laser and high power microwave weapons.

- (U) Program Plans:
- Conduct system trade studies and preliminary design.
  - Demonstrate key technologies.
  - Fabricate and characterize demonstrator.
  - Conduct ground-based performance demonstrations with a high energy laser.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

R-1 Line Item No. 16

Page 60 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-13				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Network Centric Enabling Technology TT-13	60.225	68.067	72.699	81.966	92.458	92.258	92.258	92.258

**(U) Mission Description:**

(U) This project provides technology to build mission applications explicitly tailored to exploit the features of network-centric system architectures. Mission applications include signal processing, detection, tracking, identification, situation understanding, planning, and control functions. These applications will integrate: (1) external sensors and processors that provide data on targets and mission contexts; (2) external platforms, both air and surface, that deliver sensors and munitions to designated areas; (3) intelligence processing systems at all levels of command; and (4) external communications networks that provide connectivity between computing nodes located on the platforms, at field command centers, and headquarters. The mission applications share data to form consistent battlespace understanding tailored to the needs of commanders at each node. The types of tailoring include common operational pictures, timelines, and resource usage descriptions. The mission applications also negotiate plans for future operations based on mission needs presented at each node. To maintain focus on operationally relevant problems, the project's technical goals are posed and evaluated in the context of mixed manned/unmanned forces.

(U) Technologies developed in this project enable localized and distributed collaborative processing. This allows networks of sensors to rapidly adapt to changing force mixes, communications connectivity, and mission objectives. The technology developed permits the distributed command and intelligence systems to effectively collaborate in a dynamic environment. Technologies are demonstrated and evaluated in the laboratory and in hardware-in-the-loop demonstrations. Demonstrations employ both stationary and autonomous mobile platforms. Operational benefits are: (1) smaller forward deployment of image and signal analysts in complex operating conditions including urban battlefields; (2) deeper understanding of the evolving stability and support operational environment; (3) consistent integration of target and environment information; and (4) flexible operational tactics and procedures to find evasive targets in difficult environments.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-13	

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Networked Embedded Systems Technology (NEST)	4.000	6.000	4.000	3.000

(U) The Networked Embedded Systems Technology (NEST) program provides robust coordination and synthesis services for sensor network systems. NEST is the key software building block needed to enable ad-hoc or structured wireless sensor networks to function together. Applications of these systems include: localization of snipers by collaborative sensor fusion in real time (i.e., within two seconds), sensor network-based tripwires and chokepoints for detection and discrimination of personnel and vehicles, and wide-area, 24/7 surveillance of long linear structures, (i.e., pipelines and borders). These applications require from tens to tens of thousands of nodes. NEST produces reusable software libraries and design tools that simplify the development of wireless sensor network applications.

(U) In particular, this technology is being combined with an active exciter to develop a radar-like sensor system to measure human activity inside buildings. The approach exploits existing wiring networks (power) to provide persistent surveillance of buildings and below grade areas. The concept is to insert radar pulses into a building's main power feed and read pulse returns from a wireless network of sensors placed around the building. The building's own wiring network serves as a transmission line to conduct these pulses throughout a structure, and every outlet or switch serves as an antenna to couple these radar waves to and from free-space.

**(U) Program Plans:**

- Develop tools for the automatic composition and verification of application-specific coordination service packages; demonstrate the utility of these tools in a fully integrated system consisting of a large network of heterogeneous sensors.
- Develop tools for remotely reprogramming large scale sensor networks and services for authentication and data encryption in those networks.
- Develop and populate a repository of customizable/adaptable services for real-time coordination and synthesis that support military applications.
- Develop prototype pulsing and sensing system to measure phenomenology, insertion losses, and radiation efficiency.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

- Demonstrate, in non-real time experiments, target localization and tracking in a realistic multi-story urban structure.
- Conduct final field experiments and Military Utility Assessments.

	FY 2006	FY 2007	FY 2008	FY 2009
Combat Zones That See (CZTS)	7.436	5.000	6.000	8.000

(U) The Combat Zones That See (CZTS) program improves the situational awareness, effectiveness, and safety of U.S. military forces in foreign urban environments (e.g., Mozul). CZTS provides close-in sensing and extended reconnaissance capabilities using a network of video sensors. The system tracks vehicles over urban areas using sparse arrays of video cameras, automatically detecting vehicles that may be involved in hostile activities based on the observed tracks. This network produces an extreme amount of raw data, precluding human analysis, so advanced video understanding algorithms embedded in commercial-off-the-shelf hardware systems monitor the video feeds automatically. As processing requirements become well-understood, novel image-processing chips will be integrated and interleaved with focal plane arrays within a conventional camera architecture, and a fully-compatible communications link developed to support a video-based system for perimeter defense. CZTS will enable vehicle identification with a 10,000-fold reduction in the bandwidth required to transmit key data across the camera network and will provide the capability to track vehicles non-continuously across extended distances. The CZTS goal is to demonstrate technology packaged into a flexible ground-deployed system.

(U) Program Plans:

- Developed, installed overseas, and evaluated a force protection prototype that employs approximately 30 cameras.
- Demonstrated sustained tracking of individual vehicles using sensors whose fields-of-view do not overlap.
- Use vehicle track data to calibrate cameras, learn patterns of activity, and retrieve similar or related events from a track database.
- Employ motion-pattern analysis to assist in finding common elements among collected tracks.
- Develop techniques to optimize the location and orientation for emplacing cameras.
- Develop methodologies for the efficient and timely management of the video network.
- Simulate the processing of pixel information in the image plane of video camera, to distinguish fundamental features of humans/animals/machines, such as the cooperative movement of aggregate pixel features.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

- Demonstrate semiconductor circuitry for integration within the image plane of the camera, to process pixel information in an energy-efficient way for identification for perimeter intrusion.
- Demonstrate the completed video sensor system, for actual determination of human/animal/machine penetration of a perimeter defensive system.
- Develop, install, and evaluate a rapid deployment prototype using approximately 100 rapidly deployed cameras.

	FY 2006	FY 2007	FY 2008	FY 2009
Automated Battle Management	13.723	17.400	20.418	18.328

(U) The pace of battle will continue to increase as more-capable platforms and higher-bandwidth communication networks become operational. While experienced commanders are required to formulate strategy and select tactics, the increased operational tempo will demand more automation of low-level decision processes, such as route-finding, weapon/target pairing, and sensor scheduling. Some elements of these processes, such as collision avoidance and navigation, will be embedded in each platform. However, groups of platforms will be able to execute cooperative tactics to achieve coordinated effects. This cross-platform coordination and synchronization requires new technologies that can carry out aggregate maneuvers and tasks, while leveraging the functions embedded in each platform. This program is developing novel technologies for multi-platform, automated battle management at the tactical level, in the air, on the ground, and within mobile sensor networks.

- The Collaborative Networked Autonomous Vehicles (CNAV) program develops autonomous control methods to cause a distributed set of unmanned undersea vehicles to self-organize and distribute tasks through judicious transactions conveyed over a shared communications network. CNAV illustrates these capabilities through development of a capability for submerged target detection, localization, and tracking in restrictive littoral waters. CNAV provides this capability by creating a field of dozens or hundreds of vehicles, networked through acoustic wireless communications. The vehicles work collaboratively and autonomously to detect, classify, localize and track target submarines transiting the field. The field self-organizes to adapt to changes in target locations, environmental conditions, and operational factors. A reach-back capability allows reporting of field health and enables high-level orders and control functions to be provided to the field. CNAV will also result in a significant reduction in the cost per square mile for submerged target detection in littoral waters.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

- The Organic Sensor Exploitation Network (OSEN) program goal is to provide truly persistent, all-weather, day/night surveillance of a large ground area from the air using multiple radars providing imagery and target detection data at a high revisit rate. The objective is to move processing closer to the sensor to reduce the need for expensive communications back to a central site and provide robustness to unexpected loss of platforms, communications disruptions, and unpredictable target behavior. OSEN is developing technology to: (1) permit on-board exploitation of sensor data from remotely deployed sensor nodes; (2) support correlation of information developed across different platforms; (3) detect, track, and identify targets in the field-of-view of a platform; (4) cue other sensors to acquire a target; (5) develop effective low-cost, light-weight radars and (6) transition targets to other platforms as different targets move through sensor fields-of-view. OSEN system-level studies evaluate the relative value of different sensor mixes against low-flying aircraft, ground vehicles, dismounted infantry, and irregular forces. The program accommodates variable communications connectivity, moving processing loads from one vehicle to another as network topology changes due to platform motion.

(U) Program Plans:

- Collaborative Networked Autonomous Vehicles (CNAV)
  - Develop secure, robust underwater wireless communications and networking.
  - Perform intelligent routing of threat characteristic and track data through the field to alert CNAV nodes down stream to position or reposition for target pursuit and intercept.
  - Demonstrate fully autonomous and collaborative CNAV field deployment, autonomous field set-up and self-localization, distributed common tactical operational picture, self-healing and reconfiguration, and threat pursuit and interception.
  - Demonstrate collaborative automated target detection, classification, localization and tracking.
- Organic Sensor Exploitation Networks (OSEN)
  - Define representative sensor mixes and operational scenarios.
  - Perform analytical trade studies to generate representative sensor network components and tactics.
  - Develop a network node architecture adaptable to the devices present at that node.
  - Design and develop a radar system, which demonstrates the component hardware and signal processing technologies needed to realize a small-unmanned aerial vehicle (UAV)-based radar constellation.
  - Develop signal processing and exploitation algorithms for multi-platform radar imagery and moving target detections.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

- Prototype candidate algorithms for each function (search, detect, track, identify, correlate, hand off) and for constellation resource management, scheduling and control based on alternative technologies.
- Evaluate candidate algorithms in a synthetic environment to calibrate and verify performance models.
- Insert selected algorithms into a hardware-in-the-loop testbed; demonstrate practical utility and verify system performance.

	FY 2006	FY 2007	FY 2008	FY 2009
Urban Warfare Robotic Surveillance (URS)	10.600	6.920	0.000	0.000

(U) The Urban Warfare Robotic Surveillance System (URS) program develops new mobile sensor systems, carried on both long-endurance ground and short-endurance air platforms, to support warfighter operations in constrained urban environments. URS is exploring a mix of sensor technologies (normal and infrared video, active optics, radar, acoustic, magnetic, chemical, and RF direction finding). Sensors are being tested in environments characterized by complex multi-path propagation, limited lines-of-sight, and frequent obscuration. Platforms and sensor networks are being designed to operate in urban exterior, underground, and indoor environments. Communications repeaters and routers will be included for terrestrial connectivity to all platforms that also provide for autonomous operation if communications are interrupted. The program includes means to resupply fuel and power to forward-deployed platforms. A program demonstration will deliver a prototype robotic squad that will provide integrated urban surveillance to augment or replace dismounted infantry in dangerous operations. URS missions include route clearing, flank protection, tunnel clearing, and scout and peacekeeping operations in urban environments. The URS program also supports the DARPA Urban Challenge.

(U) Program Plans:

- Developed alternative sensor models and algorithms (signal processing, object detection, object recognition, mapping, correlation, tracking, and route generation and communications management).
- Compared alternatives in the synthetic testbed. Select combinations that offer the most robust and effective performance.
- Construct a software testbed where candidate system components can be exercised in a synthetic urban battlespace.
- Build a hardware testbed incorporating selected component sensors and algorithms.
- Exercise test platforms in a series of increasingly difficult mission/environment combinations.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

- Improve sensors or algorithms that limit performance.
- Fund technology development contracts and program planning support for the DARPA Urban Challenge.

	FY 2006	FY 2007	FY 2008	FY 2009
Home Field	7.790	13.700	15.000	14.000

(U) The Home Field program develops networked video and Laser Detection and Ranging (LADAR) processing technology to rapidly and reliably update a 3D model of an urban area. It provides 3D situational awareness with sufficient detail and accuracy to remove the “home field advantage” enjoyed by opponents. Detailed mobility maps to support ground vehicle routing will be inferred and generated, and detailed visibility data to support sensor positioning will then be derived to maximize coverage and minimize detectability. High fidelity baselines will be created to support change detection to cue searches for targets and anticipate changes due to current or impending meteorological events. The program will supply real-time context information to sensor managers, maneuver controllers, weapons operators, and commanders. Furthermore, the program will filter natural change from artificial change indicative of human (threat) activity and permit operation of military forces in hostile terrain normally deemed favorable to opponents because of their historical familiarity with hide points, sight lines, and mobility characteristics.

(U) Home Field also provides high resolution 3D data that can drive novel 3D display concept. A new element of Home Field is the Urban Photonic Sandtable Display (UPSD) project, which develops and demonstrates interactive holographic display of complex volumetric 3D data to replace current 3D visualization technologies that are either static or have limited effective field-of-view. The UPSD project is developing a 3D display system that is scalable, operates at full video rate, includes color, and supports a wide viewing angle. The result will be the world’s first full-motion 3D imaging technology system.

(U) Program Plans:

- Conducted a validation demonstration on a 1-foot by 1-foot active hogel design for the UPSD.
- Validated a monochrome active hogel-based proof-of-concept display by transforming computer data into optical data, making sophisticated integration possible to optimize image quality.
- Demonstrate a 3D-model method that used distributed video and LADAR cameras in a mixed urban environment.
- Demonstrate the ability to extract architectural features, such as windows and doors, from close-in imagery.

**UNCLASSIFIED**

R-1 Line Item No. 16

Page 67 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

- Demonstrate an effective man-machine interface to edit/update the extracted features.
- Demonstrate a model update approach that keeps the urban cartographic representation current.
- Fully develop an active hogel module to provide necessary optical and electrical performance.
- Build and customize the active hogel modules into 2-foot by 2-foot and 3-foot by 3-foot systems.
- Operate the final system at full video rate, color display, and with the possibility of tiling to larger display scales (e.g., 6-feet by 6-feet).

	FY 2006	FY 2007	FY 2008	FY 2009
Adaptive Reflective Middleware Systems	6.120	7.860	8.000	8.000

(U) The Adaptive and Reflective Middleware Systems (ARMS) program is developing an integrated open system computing and information architecture. The initial focus is on the Total Ship Computing Environment in the DD(X) Future Surface Combatant Family of Ships; however, the technology is applicable to other network-centric DoD systems. This environment executes all tasks and mission applications optimized at the platform level, rather than the subsystem level. Autonomous computing systems require middleware and frameworks that adapt robustly to changes in environmental conditions. ARMS middleware coordinates the exchange of information predictably, scalably, dependably, and securely among shipboard entities by employing advanced Quality of Service capabilities of the underlying network and end systems.

- (U) Program Plans:
- Defined and prototyped algorithms, adaptive protocols, patterns, and technologies.
  - Developed technologies to enable the use of the Java programming language in time-critical applications.
  - Enforced security policies to enhance and support secure resource allocation, scheduling, and control; ensured stability and dependability across the intra-ship network.
  - Developed robust meta-programming policies and mechanisms based on standards-based middleware.
  - Define and prototype reflective techniques for synthesizing optimized distributed, real-time, and embedded middleware.
  - Develop required information models, algorithms, and technologies; develop technologies to configure customizable, standards-compliant middleware and applications.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

- Develop robust adaptive protocols, algorithms, patterns, and technologies that exploit standards-compliant middleware.
- Develop and capture design expertise in information models. Formalize the successful techniques and constraints associated with building, generating, and validating middleware frameworks and protocol/service components for the DD(X) baselines.
- Demonstrate mature, standards-based middleware technologies for transition to the DD(X) Surface Combatant Family of Ships.

	FY 2006	FY 2007	FY 2008	FY 2009
Integrated Crisis Early Warning System (ICEWS, formerly PCAS)	3.156	5.747	6.000	8.000

(U) The Integrated Crisis Early Warning System (ICEWS, formerly PCAS, Pre-Conflict Anticipation and Shaping) program will develop and integrate a set of data analysis tools into a unified information system to support Theater Security Cooperation. The ICEWS system will monitor, assess and forecast leading indicators of events that make countries vulnerable to a variety of national and international crises. ICEWS technologies include quantitative and computational social science modeling and simulation, scenario generation, ontological modeling of security problems, advanced interactive visualization techniques, and agent-based programming. When integrated, these tools allow combatant commanders and their staff to understand and anticipate conditions that precipitate instability and conflict - while there is still time to influence them. ICEWS also helps anticipate unintended consequences of actions taken to influence or remediate situations - consequences that may be delayed by months or years.

- (U) Program Plans:
- Augment social science models with emerging computational social science model and theories.
  - Obtain and organize a large corpus of data describing a representative set of countries and regions in Pacific Command (PACOM) that are expected to range from stable to highly unstable social dynamics.
  - Build tools to automatically translate the data corpus into a form usable by quantitative and computational social science models.
  - Develop new crisis monitoring and forecasting models across multiple timescales and levels of analysis.
  - Integrate in a real-time analytical system.
  - Conduct regular experiments to assess predictions in an operational environment.
  - Develop tools that can be transitioned to the staff at Combatant Commands (PACOM HQ).

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

	FY 2006	FY 2007	FY 2008	FY 2009
Diagnostic Network Economies	3.000	4.000	3.000	3.000

(U) The Diagnostic Network Economies program will obtain orders of magnitude improvement in the speed, accuracy, and efficiency of fault diagnosis in distributed systems that provide support for crucial network centric military operations, such as transmitting a common operational picture and maintaining information dominance. As network centric warfare systems are introduced, the management systems that are needed to operate these networks must become exceptionally robust. The Diagnostic Network Economies program will substantially reduce the risks associated with network-centric operations, and at the same time assure the agility of U.S. forces by developing effective network fault diagnosis capabilities that minimize the logistical footprint associated with that aspect of network management and reduce the opportunities for human error in the process.

(U) Program Plans:

- Leverage and extend the available techniques for information fusion across multiple data sources, and anomaly detection.
- Explore new approaches to reasoning in the presence of partial and unreliable information.
- Research new approaches to discover and maintain dependencies within network centric warfare systems.
- Research networking architectures that sidestep diagnostic complexity by deliberately inducing simpler diagnostic problems.

	FY 2006	FY 2007	FY 2008	FY 2009
Visualizing the Info Ops Common Operating Picture (VIOCOP)	0.000	0.000	3.125	5.000

(U) The goal of the Visualizing the Info Ops Common Operating Picture (VIOCOP) program is to provide a commander with a standardized and logical way of depicting the impact of Information Operations on conventional missions. Great strides have been made in digitizing the battlefield and developing standardized sets of representations for the commander to visualize the physical battlefield. However, the area of information operations concerns operations that do not map cleanly to “kinetic” operations and geography. An informationally rich and succinct visual representation of non-geographic, non-kinetic information operations is needed to appropriately assess progress during an information

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

operations campaign as well as to understand interactions with ongoing conventional operations. Information operations require the commander to understand issues and impacts that may be well outside his defined area of responsibility but have significant consequences to the success (or failure) of a mission.

- (U) Program Plans:
- Research a meaningful symbology and depiction of information operations concepts for the broadest definition of information operations (to include technical, social, geographic, cultural, tactical, cyberdefense, etc.).
  - Prototype a digital information operations picture using this symbology that is integrated with the Commander's common operation picture.
  - Research human-computer interfaces to visualize and manipulate information operations data.
  - Research a modeling and simulation capability for information operations.
  - Research mechanisms to integrate the tactical picture with the information operations information.

	FY 2006	FY 2007	FY 2008	FY 2009
Very High Speed Torpedo Defense	0.000	0.000	4.156	8.638

(U) The Very High Speed Torpedo Defense program will develop concepts for U.S. ship defense systems to defeat very high speed (250 knot) rocket-powered super-cavitating torpedoes currently under development by other nations. Queued by a ship's sonar system, the torpedo can be identified and localized using a large search volume laser-radar tracking system that can be used to compute a firing solution. The torpedo will then be engaged using specially designed high speed projectiles (also super-cavitating) fired from the ship to neutralize the incoming threat.

- (U) Program Plans:
- Validate preliminary sensor and weapon concepts.
  - Design and test final system components, including the laser sensor, the cueing and targeting mechanism, and the projectile weapons.
  - Demonstrate and test the entire system using test rigs and lake facilities.
  - Conduct a final series of ocean tests in a variety of sea state conditions.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

	FY 2006	FY 2007	FY 2008	FY 2009
Kick Stand	0.000	0.000	3.000	6.000

(U) This effort will use directed ultrasound technology to enable the capability to significantly reduce sound emissions from large scale tactical military hardware. Theory predicts that nonlinear effects of high-power acoustic radiation on the atmosphere can cause acoustic energy to dissipate rather than radiate. This theory has been confirmed in some limited experiments; this program will apply it to reducing acoustic emissions of U.S. equipment. Reduction in noise levels by at least 30dB would enable U.S. forces to effectively operate considerably closer to enemy forces without being detected aurally.

(U) Program Plans:

- Validate the theoretical models in laboratory settings.
- Estimate power levels and secondary effects required to sustain an ultrasonic curtain around a vehicle.
- Demonstrate absorption of transverse acoustic energy through a vertically projected ultrasonic field.
- Design a complete system for shielding a truck-sized vehicle.
- Demonstrate shielding for a stationary vehicle.
- Conclude with a field demonstration of a vehicle operating over a military test range.

	FY 2006	FY 2007	FY 2008	FY 2009
R31 Systems: Next Generation of Intelligent Communications	1.700	1.440	0.000	0.000

- Selected and continue to fund initiatives for the next generation of intelligent communications.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Tactical Technology PE 0602702E, Project TT-13	

	FY 2006	FY 2007	FY 2008	FY 2009
Enhancement of Communications and Telemetry Support	1.700	0.000	0.000	0.000

(U) Selected and funded initiatives for the enhancement of communications and telemetry support.

	FY 2006	FY 2007	FY 2008	FY 2009
MESH-Enabled Architecture	1.000	0.000	0.000	0.000

(U) Selected and funded initiatives for MESH-enabled architecture.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**  
R-1 Line Item No. 16  
Page 74 of 74

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research			<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E					
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	271.356	298.147	306.022	303.363	281.107	288.107	288.107	298.107
Materials Processing Technology MBT-01	162.908	169.052	195.432	200.814	195.772	192.772	192.772	202.772
Biologically Based Materials and Devices MBT-02	108.448	129.095	110.590	102.549	85.335	95.335	95.335	95.335

**(U) Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technologies related to those materials and biological systems that make possible a wide range of new military capabilities.

(U) The major goal of the Materials Processing Technology project is to develop novel materials, materials processing techniques, mathematical models, and fabrication strategies for advanced structural and functional materials and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of materials including: structural materials and devices, smart materials and actuators, functional materials and devices, and materials that are enabling for improvements in logistics.

(U) The Biologically Based Materials and Devices Project acknowledges the growing and pervasive influence of the biological sciences on the development of new materials, devices and processes, as well as the commensurate influence of materials, physics and chemistry on new approaches to biology and biochemistry. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the development of biochemical materials to maintain performance, the use of biology's unique fabrication capabilities to produce structures that cannot be made any other way, the application of magnetic materials in biological applications, and the development of manufacturing tools that use biological components and processes for material synthesis. It also supports a major thrust that will revolutionize the development of prosthetics for the wounded soldier.

**UNCLASSIFIED**

R-1 Line Item No. 17

Page 1 of 24

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials & Biological Technology PE 0602715E	

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	288.753	297.277	308.261	315.107
Current Budget	271.356	298.147	306.022	303.363
Total Adjustments	-17.397	.870	-2.239	-11.744
Congressional program reductions	-10.000	-3.130		
Congressional increases	0.000	4.000		
Reprogrammings	0.000			
SBIR/STTR transfer	-7.397			

(U) **Change Summary Explanation:**

FY 2006	The decrease reflects the SBIR/STTR transfer and the Section 8040 rescission.
FY 2007	The increase reflects a congressional add to Strategic Materials which is offset by a congressional cut to Neurotechnology for Intelligence Analysts and a reduction for Section 8106 Economic Assumptions.
FY 2008/2009	Changes reflect minor repricing of materials and biological systems programs.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Materials & Biological Technology PE 0602715E, Project MBT-01				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Materials Processing Technology MBT-01	162.908	169.052	195.432	200.814	195.772	192.772	192.772	202.772

**(U) Mission Description:**

(U) The major goal of this project is to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components that will lower the cost, increase the performance, and/or enable new missions for military platforms and systems. Included in this project are efforts across a wide range of materials including: structural materials and devices, smart materials and actuators, functional materials and devices, and materials that are enabling improvements in logistics.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Materials Processing and Manufacturing*	22.000	23.150	29.299	31.500

\*Previously this was part of Structural Materials

(U) The Materials Processing and Manufacturing thrust is exploring new manufacturing and processing approaches that will dramatically lower the cost and decrease the time it takes for DoD systems to be fabricated. It will also develop approaches that yield new materials and materials capabilities that cannot be made through conventional processing approaches. Included are disruptive manufacturing approaches for raw materials and components. Finally, new materials, coating and fibers are being developed that will directly improve the performance and/or lifetimes of DoD systems and components.

**(U) Program Plans:**

- Demonstrate and validate mathematical models and other critical technical issues for the accelerated insertion of materials that will allow designers to cut the insertion time of new materials by over 50 percent using materials of high value to DoD (turbine metals, aircraft structures).

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-01	

- Explore techniques for large volume, low cost synthesis and assembly of nanomaterials and nanotubes with controlled attributes that are suitable for high toughness fibers and reinforcements; demonstrate these reinforcement concepts in structural composites in defense applications such as advanced blast and ballistic damage tolerance.
- Demonstrate novel, cost effective processing routes for aerospace grade (low oxygen) titanium metal and alloys. Explore processing routes for other structural materials of interest to defense.
- Develop and demonstrate manufacturing technologies that can lead to significant reduction in DoD system cost, especially for low volume.
- Demonstrate novel and reproducible process routes for directed, localized and controlled microstructure modification to achieve substantial improvements in structural material properties of interest to defense, including bronze castings for Navy applications.
- Develop and verify models that predict bulk amorphous metal formation and behavior; use these models to produce amorphous materials and coatings with superior properties (including increased fracture toughness and high strain rate behavior and long-term corrosion resistance in saline environment) over crystalline material.
- Demonstrate structural materials fabrication (forming, joining, etc.) technologies that yield bulk amorphous metals suitable for defense applications, including composites for space applications with 25% reduction in weight and 50% increase in specific properties and aluminum based amorphous alloys for turbine blade applications.

	FY 2006	FY 2007	FY 2008	FY 2009
Multifunctional Materials and Structures*	7.400	17.233	25.500	26.000

\*Previously this was part of Structural Materials

(U) The Multifunctional Materials and Structures thrust is developing approaches for producing materials and structures that are explicitly tailored for multiple functions and/or unique mechanical properties. Included in this thrust are efforts that will lower the weight and increase the performance of aircraft, ground vehicles, blast/ballistic protection and spacecraft structures. This includes new approaches for topologically controlled armor and new structural designs aimed at defeating explosively formed projectiles (EFPs).

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-01	

(U) Program Plans:

- Develop multifunctional materials concepts designed to provide significant improvement in the capabilities of defense systems by providing additional functions (e.g., self-healing, thermal control, blast protection, and power) to load bearing structures, quantify their performance and fabricate specific prototype systems.
- Develop a low cost, protective system based on novel material structures and topology to protect troops and trucks against ballistic threats, shrapnel and blasts from improvised explosive devices.
- Establish and demonstrate up to 20% performance improvements and engine durability of high performance gas turbine engines based on vaporization cooling.
- Demonstrate that nano boron carbide powders can be pressurelessly sintered to produce armor exceeding the Level IV Department of Justice (30 cal AP) standard but at a lower cost and with the ability to produce complex shapes for greater comfort and protection.

	FY 2006	FY 2007	FY 2008	FY 2009
Prognosis*	19.559	10.669	12.000	12.000

\*Previously this was part of Structural Materials

(U) The Prognosis thrust is aimed at demonstrating a revolutionary new concept that uses physics-based models and advanced interrogation tools to assess damage evolution and predict future performance of the structural materials in defense platforms/systems. Included are demonstrations on Navy aircraft structures and engines for advanced jet aircraft. Also included are sensor and model development required to support the damage prediction.

(U) Program Plans:

- Develop models, mathematical techniques and novel sensors that when integrated with sensor data will capture the physics of failure and behavior prediction in materials suitable for assessing in-situ damage accumulation and will also provide current state awareness and structural performance prediction for defense systems.
- Demonstrate the use of flight information to predict life and failure of critical structural components thereby increasing the useful life by five times.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Smart Materials*	13.344	15.968	21.000	21.000

\*Previously this was part of Smart Materials and Actuators

(U) This thrust is developing the next generation of smart materials for application in new DoD systems. Included in this thrust are concepts to yield “intrinsically smart” materials that provide self-diagnosis and/or self-repair. Also included are approaches to demonstrate the ability to dramatically change the structural and/or electromagnetic properties of a material in real time. Finally, new smart materials that are inspired by nature that can move rapidly, but with high force will be demonstrated.

(U) Program Plans:

- Develop and demonstrate novel fluidic and mechanical devices, and their associated driving electronics that exploit smart material transducers in order to create new high power actuators for a variety of military applications.
- Demonstrate that nano-tubes applied to a surface can diminish the heat transfer linkage between the thin boundary layer that surrounds a high speed vehicle and the heat flux into the vehicle, thereby providing a low weight, thermal barrier.
- Develop new materials that will intelligently adapt properties (e.g., modulus, strength) in response to the environment.
- Demonstrate that materials systems based with distributed force and displacement capability can produce large forces at moderate bandwidth such as helicopter blades.
- Develop technologies to create multifunctional surfaces that exhibit the desired and critical characteristics specifically designed for improving surface structural and electromagnetic properties.
- Develop chemical systems that are able to transmit optical signals at stand-off distances.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Reconfigurable Structures*	14.000	22.000	21.234	18.064

\*Previously this was part of Smart Materials and Actuators

(U) In the Reconfigurable Structures thrust, new combinations of advanced materials, devices, and structural architectures are being developed to allow military platforms to morph or change shape to adapt optimally to changing mission requirements and unpredictable environments. This includes the demonstration of a morphing aircraft as well as new materials and devices that will enable the military to function more effectively in the urban theater of operations.

(U) Program Plans:

- Design, demonstrate, and validate an integrated, untethered, and self-powered exoskeleton system for augmenting the locomotion and strength of soldiers. The interface of the machine and human will be dramatically enhanced by the development of novel sensor architectures and control algorithms.
- Demonstrate capabilities of the exoskeleton against specific military metrics and transfer to the Army.
- Develop, design, and test the actuators, materials, and control architectures necessary for achieving precise shape change in an airframe to demonstrate the advantages and enable capabilities afforded by the ability to change shape (morphing).
- Demonstrate capabilities of morphing aircraft technology in a wind tunnel.
- Develop new technologies that enable reversible adhesion with adhesive strengths greater than 1 Mega Pascals (MPa).
- Develop a rapidly deployable and reversible, portable lightweight barrier to control enemy mobility in urban areas such as intersections, alleyways, doorways, etc.
- Develop and demonstrate key smart materials technologies for plasma fueled and turbulence harvesting aircraft, including low power magnetic structures and the ability to reconfigure electromagnetic fields. Develop ultra-light high temperature capability for hypersonic vehicles using novel approaches to enable reduced thermal load, boundary layer control and virtual shape control.
- Leverage new materials concepts to develop new climbing devices and techniques that will enable quick and easy access to upper floors and rooftops of buildings.
- Develop soft chemically based materials with the ability to drastically change shape, reconfigure, and perform function.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Functional Materials and Devices	36.855	25.000	29.399	29.250

(U) In this thrust, new materials and concepts are being applied to the development of functional materials and devices. A fundamental principle of this thrust is to design material microstructures at the scale appropriate to exploit fundamental interactions with the environment in order to create materials with unique properties. Among the materials being developed in this thrust are new permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings and actuators. Engineered materials (metamaterials) are being developed that provide dramatically new electromagnetic behavior across the complete array of Defense applications. Also, this thrust exploits nanostructured materials to slow light, to produce negative index materials as well as to demonstrate an array of other functional devices (antennas, dosimeters, etc.).

(U) Program Plans:

- Develop and demonstrate novel magnetic meta-materials for DoD motor applications including: 1) high temperature, high strength soft magnetic materials for rotor and stator applications in turbine environments; and 2) permanent magnets with superior energy products.
- Develop and demonstrate novel microwave meta-materials that will enable novel antenna and radar designs with reduced size and improved bandwidth and efficiency.
- Develop and demonstrate novel materials that can be remotely switched between two stable electromagnetic and/or structural configurations, including munitions with controllable sensitivity.
- Extend the frequency of operation and/or operational bandwidth of “negative index” or “left handed” materials to demonstrate novel radio frequency (RF) and optical applications for Defense. Specific demonstrations include the reduction of ultra-high frequency (UHF) antenna size by a factor of 20 with no loss in gain and approaches for sub-wavelength focusing at infrared (IR) wavelengths.
- Develop new functional materials and devices that slow light pulses, resulting in opportunities such as tunable delay lines for optical signal processing, high-speed RF signal processing applications, and single-photon quantum devices.
- Develop high-efficiency nanostructure antenna elements and evaluate overall performance when combined into an antenna array.
- Demonstrate electric field independence and low loss electrodes.
- Select and optimize novel heterostructures capable of defining the region of photonic sensitivity.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-01	

- Design materials and device architectures for a flexible wearable platform that records the real-time exposure to traumatic blast pressures due to an explosion.

	FY 2006	FY 2007	FY 2008	FY 2009
Materials for Power*	19.400	15.552	19.000	21.000

\*Previously this was part of Materials for Logistics (Air, Water, Power)

(U) The Materials for Power thrust will explore new materials solutions to enable power to be efficiently generated and controlled. This includes new materials concepts to increase the efficiency and robustness of portable fuel cells as well as the exploitation of nanotechnology to increase the efficiency and lower the weight of batteries. New materials and designs will also be applied to the development of novel mesoscale engines (e.g., Stirling, water lubricated steam engines) that will provide needed power on the battlefield. Hybrid superconducting/cryogenic components will provide a new paradigm for power electronics for the “all electric” platforms of the future. Materials technology is also being developed to enhance power conditioning for large power applications such as Navy ships, as well as approaches to generate energy directly from heat. Finally, solar cells will be developed that will demonstrate at least 50% efficiency in an affordable, manufacturable photovoltaic (PV) device through the development and fabrication of novel components such as device-grade quality PV materials, electronic doping, nanostructure process control, and the integration of the process capabilities with current micro- and nano-fabrication tools.

(U) Program Plans:

- Develop and demonstrate in a real military environment an efficient, low cost, 400 Watt Stirling engine for Defense applications, including powering of small, motorized vehicles.
- Design, develop, and demonstrate robustness of portable power sources in the 20 Watt power range suitable for several mission scenarios including: 1) a three hour micro air vehicle reconnaissance mission; 2) a three day land warrior mission; and 3) a ten day special operation forces mission.
- Demonstrate the design of lightweight, rugged packaging and power control strategies for man-portable fuel cells that will allow robust, orientation invariant operation throughout a military mission and demonstrate this capability in concert with military transition partners.
- Demonstrate concepts for highly power-dense, man-portable kilowatt generators that will reduce the logistics burden for the soldier in the field.

**UNCLASSIFIED**

R-1 Line Item No. 17

Page 9 of 24

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-01	

- Demonstrate materials and components for a hybrid superconducting power system for a terrestrial (>5 MW) application that has high efficiency and reliability and the potential for significantly reduced size (10x) and weight (5x).
- Develop and demonstrate enabling direct thermal to electric conversion technologies with potential for high (> 20%) conversion efficiencies and high (> 1 W/cm<sup>2</sup>) power densities for DoD and commercial power generation applications.
- Demonstrate efficiency of solar cell optics and converter technologies in high, mid, and low energy photon environments.
- Demonstrate an integrated solar cell of at least 10 cm<sup>2</sup> area, delivering 500 W/m<sup>2</sup>.
- Develop novel concepts for extremely high efficient solar cells (>50%) and novel solar cell configurations for battlefield deployment.
- Increase energy/power density for same weight/volume enabling 15lb weight reduction for dismounted soldier on 3-day mission.

	FY 2006	FY 2007	FY 2008	FY 2009
Alternate Power Sources*	15.300	26.980	27.000	27.000

\*Previously part of Materials for Logistics (Air, Water, Power)

(U) The Alternate Power Sources thrust is examining novel approaches to obtaining power in the battle environment. This included an effort to demonstrate the feasibility of open ocean, littoral and freshwater prototype fuel cell systems, capable of generating continuous, unattended electrical power for greater than 10 years. Also being developed are concepts to covert military waste (plastic, paper, food) directly into energy at over 90% conversion efficiencies. Additionally, this thrust is exploring longer term, higher risk approaches to obtaining and using energy. A pathway to self-sustainable agriculture-sourced production of an alternative to petroleum-derived JP-8 that will meet all DoD needs will be investigated to achieve a 60% (or greater) conversion efficiency, by energy content, of crop oil to JP-8 surrogate and elucidate a path to 90% conversion.

(U) Program Plans:

- Demonstrate processes that can convert military waste directly into usable power for the military.
- Exploit advances in nanotechnology to achieve battery systems with a 3X increase in energy density to 400 Watt hours/kg, and a 5X increase in power density to 1000 Watt/kg with a 30% decrease in weight.
- Explore unconventional power sources that might yield new, efficient approaches to providing power to the battlefield.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-01	

- Establish techniques for suppression of neutron and gamma emission in compact alpha emitter nuclear power generators (a safety issue) and verify methods for suppression of radiation-induced damage in nuclear energy converter mechanisms.
- Designed, fabricated and tested laboratory models for sediment mounted and water column microbial fuel cells.
- Designed, fabricated and tested preliminary sediment mounted and water column microbial fuel cells.
- Developed preliminary models for estimating power output as a function of microbial speciation and chemical reductant/reactant concentrations.
- Design, develop, and demonstrate a process pathway for >60% conversion (by energy) of crop oil to jet fuel surrogate.
- Elucidate a path to 90% conversion of crop oil to jet fuel surrogate.

	FY 2006	FY 2007	FY 2008	FY 2009
Long Duration Power Concepts*	7.923	8.500	11.000	15.000

\*Previously this was part of Materials for Logistics (Air, Water, Power)

(U) The requirement for generating power over long duration missions proposes unique challenges in energy storage, power conditioning and overall integration. This thrust is exploring the breakthroughs in power generation needed for extremely long duration, unmanned applications including unmanned underwater vehicles (UUVs) and unmanned air vehicles (UAVs). These include energy storage approaches that are structurally efficient as well as energy efficient. It also includes approaches for efficiently removing the energy at rates commensurate with the high sprint power often required in these applications.

(U) Program Plans:

- Develop novel power components (e.g., fuel cells, structural batteries) that have the potential for demonstrating energy densities in the range of 1000-1500 Watt-hours per liter (W-hr/l) for UUV applications.
- Demonstrate a 300% increase in small UAV endurance by harvesting solar thermal energy conversion to efficient propulsive power.

**UNCLASSIFIED**

R-1 Line Item No. 17

Page 11 of 24

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials and Electronics Technology PE 0602715E, Project MBT-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Strategic Materials	2.550	4.000	0.000	0.000

- (U) Program Plans:
- Development continued on reliable, robust, repeatable, and cost effective Chemical Vapor Composite (CVC) SiC manufacturing process for high tech military, space, and industrial applications.

	FY 2006	FY 2007	FY 2008	FY 2009
Water Harvesting Technologies	2.377	0.000	0.000	0.000

- (U) Program Plans:
- Developed and demonstrated unique, energy-saving concepts for obtaining water from non-traditional sources (e.g. water-from-air), for the individual warfighter and small groups of soldiers.

	FY 2006	FY 2007	FY 2008	FY 2009
MMI/MBI Nanotechnology Solutions	0.400	0.000	0.000	0.000

- (U) Program Plans:
- Investigated new approaches and accelerated the research of leading-edge nano-scale technologies for potential Defense applications.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials and Electronics Technology PE 0602715E, Project MBT-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Characterization, Reliability & Applications of 3-D Microstructures	1.800	0.000	0.000	0.000

- (U) Program Plans:
- Continued the development of key technologies behind a packaging concept that used a stacked multi-chip module approach to reduce interconnect length and increased physical connectivity between layers of electronics.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

R-1 Line Item No. 17

Page 13 of 24

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 17  
Page 14 of 24

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Materials & Biological Technology PE 0602715E, Project MBT-02				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Biologically Based Materials and Devices MBT-02	108.448	129.095	110.590	102.549	85.335	95.335	95.335	95.335

**(U) Mission Description:**

(U) This project acknowledges the growing and pervasive influence of the biological sciences on the development of new materials, devices and processes as well as the commensurate influence of materials, physics and chemistry on new approaches to biology and biochemistry. Contained in this project are thrusts in the application of biomimetic materials and devices for Defense, the development of biochemical materials to maintain performance, the use of biology’s unique fabrication capabilities to produce structures that cannot be made any other way, the application of magnetic materials in biological applications, and the development of manufacturing tools that use biological components and processes for materials synthesis. It also supports a major thrust that will revolutionize the development of prosthetics for wounded soldiers.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Bioinspired Locomotion and Sensing*	31.193	33.000	21.620	15.214

\*Previously this was part of Bioinspired and Biderived Materials

(U) The Bioinspired Locomotion and Sensing thrust explores approaches to capture the biological systems’ ability to move and sense and emulate these in man-made robotic or sensor systems. This includes providing robotics with the mobility required to provide support to soldiers in all terrains, including climbing. This thrust also includes a program to develop synthetic optics that mimics the advantages and adaptability of biological lenses and sensors that can detect infrared (IR) and vibration at biological levels, which are far below that of current man-made detectors.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-02	

- (U) Program Plans:
- Explore new bioinspired locomotion in robotic systems and develop power efficient, systems-level bio-locomotion for mobility in rough/loose terrain and in unusual locomotion environments, i.e., vertical (>60°) and inverted surfaces.
  - Demonstrate biomimetic sensory prototypes and materials that collect electromagnetic olfactory and visual inputs.
  - Develop signal transduction technology that directly converts biological macromolecular activity (sensing/binding/conformation changes) into an appropriate electrical or optical signal output for the development of biomimetically based sensors (uncooled IR, optical, etc.).
  - Develop material systems based on biological principles that distribute the force and displacement capability of a hydraulic system continuously throughout a structure. Demonstrate these materials in systems that require large forces at moderate bandwidth such as helicopter blades.
  - Develop new biomimetically based swimming devices that will double the speed for combat swimmers, including SEALs and Marines, while decreasing energy consumed by a factor of eight.
  - Develop new materials that will allow the demonstration of lightweight, compact, bio-inspired optical devices. Demonstrations will include a 30x zoom lens of a size to fly on the Pointer unmanned air vehicle (UAV) and a variable field of view (90-180 degrees) lens that will fly on the Dragon Eye UAV.
  - Define new, malleable materials that utilize biomimetic principles of design (e.g., emulate skin, bone, muscle, nerve endings and self-repair features) for locomotion and actuation.

	FY 2006	FY 2007	FY 2008	FY 2009
Bioderived Materials*	14.000	15.000	19.000	19.000

\*Previously this was part of Bioinspired and Bioderived Materials.

(U) The Bioderived Materials thrust explores the use of biological materials to support Defense needs. This includes using biological systems (e.g., plants) directly as sensors as well as exploiting the work and energy harvesting capabilities of biological motors.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-02	

(U) Program Plans:

- Developed an initial understanding of fish (bony and elasmobranch) sensory and sensory-motor capabilities to provide the basis for developing associated biomimetic sensor systems.
- Developed a preliminary understanding of basic sensory and motor responses using both external and internal stimulation.
- Determine and quantify the mechanism of motor function, motor performance, and efficiency for several types of biomolecular motors through computational models and experimental measurements.
- Demonstrate the utility of biomotors for specific DoD applications including high sensitivity biosensors, high efficiency solar cells and the emulation of natural muscle activity.
- Exploit stealthy sentinels, including the development of critical materials/device interfaces to address teleoperation and autonomous navigation, for their ability to be remotely guided to operationally relevant sites and generate environmental information (chemical, biological, and visual).
- Leverage naturally occurring plants to enable long duration, unattended sensors including camouflaging the device/antenna and extracting energy.

	FY 2006	FY 2007	FY 2008	FY 2009
Maintaining Combat Performance*	21.770	27.777	20.000	19.061

\*Previously this was part of Biochemical Materials

(U) The Maintaining Combat Performance thrust utilizes breakthroughs in biology, physiology, and neuroscience to sustain the peak physical and cognitive performance of warfighters operating in extreme conditions. Today, warfighters must accomplish their missions despite extraordinary physiologic stress. Examples of these stressors include extremes of temperature (-20°F to 125°F), oxygen deficiency in mountains, personal loads in excess of 100lbs, dehydration, psychological stress, prolonged periods without adequate sleep or nutrition, and even performance of life-sustaining maneuvers following combat injury. Not only must troops maintain optimum physical performance, but also peak cognitive performance, which includes the entire spectrum from personal navigation and target recognition, to complex command and control decisions, and intelligence synthesis. The balance of the warfighter’s complex duties requires constant peak physical and mental performance. The Maintaining Combat Performance thrust leverages breakthroughs in diverse scientific fields in order to mitigate the effects of harsh combat environments. For example, understanding the natural mechanisms for core body temperature regulation in hibernating mammals has led to a novel, practical

**UNCLASSIFIED**

R-1 Line Item No. 17

Page 17 of 24

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-02	

approach for soldier cooling, which is now being evaluated by troops in the far forward combat areas. Another example is research on the fundamental neurophysiologic causes of cognitive deterioration following sleep deprivation; this research has led to safe nutritional and training approaches that promise to minimize the adverse effects of short-term sleep deprivation, which is an inherent component of current operational scenarios.

(U) Program Plans:

- Develop prototype threat-warning devices by integrating electronics imaging systems with in-line bio-derived image processing algorithms.
- Implement new non-invasive biological sensors to create practical, prototype devices for using neurological signals to improve the throughput and accuracy of intelligence imagery analysis.
- Develop safe dietary formulations that are effective at maintaining the health of troops in combat.
- Develop methods for regulating core body temperature so that physical performance is maintained during training and in extreme combat environments.
- Develop an understanding of the biochemical and physiological causes of decreased cognitive performance during sleep deprivation through studying animal model systems, synaptic function, and transcranial magnetic stimulation (TMS).
- Demonstrate and validate approaches to develop biomaterials and other concepts that extend the cognitive performance capabilities of warfighters during extended periods of sleep deprivation and stress.
- Demonstrate physiological approaches to enable warfighters to conduct operations at high altitudes without prolonged altitude acclimatization.
- Develop and validate approaches that will restore the function of auditory structures injured by blast and other acoustic insults.
- Develop medical technologies that improve the effectiveness of battlefield pain management, without risk of overdose.
- Develop and validate methods for selectively reducing metabolic requirements following severe blood loss in order to extend the period of survival.
- Demonstrate induced desiccation strategies for platelets that allow prolonged periods (> 24 months) of dry storage with recovery of all critical clotting functions when rehydrated.

UNCLASSIFIED

R-1 Line Item No. 17

Page 18 of 24

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Tactical Biomedical Technologies*	18.485	22.318	21.590	22.000

\*Previously this was part of Biochemical Materials

(U) The Tactical Biomedical Technologies thrust will develop new approaches to deliver life-saving medical care on the battlefield, as well as novel technologies for reconstruction and rehabilitation of severely injured warfighters. Implicit in this thrust is the fact that there are unique, warfighter-specific challenges in acute and chronic treatment that are not addressed by civilian research and development. Today, more than half of American battlefield fatalities are due to hemorrhage, particularly due to improvised explosive devices (IEDs). To prevent these deaths, there is an urgent need for technologies that enable relatively unskilled personnel (battlefield medics) to diagnose and treat injuries, including the ability to locate and coagulate non-compressible deep bleeders in the thorax or abdomen. Ultimately, this thrust will develop and demonstrate tele-robotic, semi-autonomous trauma pods that will bring life-saving surgical care directly to the front lines. Other critical needs stem from the fact that warfighters are frequently victims of blasts, causing patterns of brain, burn, and orthopedic injuries not seen in civilian medical practice. As such, there is a unique military need to develop systems for pain control that are safe even in medically unmonitored environments, like an active battlefield. And once lives are saved, there is an unmet need for new methods to restore function, for example, by restoring long segments of bone that were lost due to blast fragmentation. Overall, this thrust recognizes the unique medical and surgical needs of warfighters, and will develop innovative technologies to save warfighters lives and restore their function to normal.

(U) Program Plans:

- Develop a lightweight version of the Life Support for Trauma and Transport (LSTAT) portable intensive care platform with innovative technologies to make the system available in the far forward battlefield for combat casualty care of wounded soldiers.
- Define and demonstrate new operating room technologies for the battlefield that reduce the need for operating personnel.
- Develop and demonstrate devices to locate and coagulate bleeding using focused acoustic energy.
- Develop a device to allow automatic insertion of an intravenous catheter in a battlefield environment, even by unskilled personnel.
- Develop novel biochemical feedback mechanisms and nanotechnology-based delivery systems to create a feedback regulated battlefield drug delivery system.
- Extend 3-D imaging approaches to a virtual autopsy capable of a more rapid and accurate post mortem wound assessment.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-02	

- Develop new bio-mechanical technologies that will significantly enhance the growth of bone in limbs injured by blast and fragmentation.
- Demonstrate the ability of plasma (ionized gases) to sterilize wound sites and battlefield medical devices.
- Develop technologies for the assessment of oxygen saturation, blood pressure, heart rate, EEG, respiratory rate, and temperature from a distance of one meter in a simulated battlefield environment.
- Develop a cognitive rehabilitation environment and explore techniques to dramatically decrease the time from battlefield injury to return to the unit.
- Develop a transportable Magnetic Resonance Imaging (MRI) system capable of field deployment to in-theater Combat Support Hospitals (CSHs) for diagnosis and assessment of traumatic brain injuries (TBI) to front-line soldiers, sailors, and airmen.

	FY 2006	FY 2007	FY 2008	FY 2009
Bio-Magnetic Interfacing Concepts (BioMagnetICs)	6.000	4.000	2.000	1.000

(U) The Bio-Magnetic Interfacing Concepts (BioMagnetICs) Materials program will develop and demonstrate novel capabilities for integrating nanomagnetism with biology and will demonstrate the advantages of magnetism as a powerful new transduction mechanism for detecting, manipulating, and controlling biological function in single cells and biomolecules. The state-of-the-art research “tools” that have allowed researchers to observe the most fundamental units of biology (cells, DNA, proteins, etc.) do not possess the resolution, precision, or high throughput capacity to enable manipulation and/or functional control of large numbers of cells and biomolecules. Such a capability would have a pervasive and paradigm shifting impact on future military and civilian applications of biotechnology including chem-bio detection, therapeutics, and medical diagnostics. Nanoscale magnetism offers the promise of a robust, non-invasive, non-destructive, multiplexing, and high throughput interface that is compatible with the nanometer scale at which the biochemistry of cellular function exists.

- (U) Program Plans:
- Develop and demonstrate a portable, magnetism-based DNA detection and readout capability for rapid determination of specific biological warfare agents.
  - Develop and demonstrate remotely addressable, magnetism-based biochemical sensors.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-02	

- Develop the capability to use magnetics to rapidly filter biotoxins from humans.
- Conduct “Proof of concept” demonstrations of the potential for portability and compact packaging of BioMagnetICS based sensor and diagnostic devices.

	FY 2006	FY 2007	FY 2008	FY 2009
Revolutionizing Prosthetics	15.000	25.000	23.500	22.000

(U) The goal of this program is to dramatically change the state of the art of prosthetics, moving them from crude devices with minimal capabilities to fully integrated, fully functional limb replacements. Current prosthetic technology generally provides only gross motor functions, with very crude approaches to control—essentially switches. This makes it difficult for wounded soldiers to return to military service. The needed advances will be accomplished by exploiting the dramatic breakthroughs of the Human Assisted Neural Devices program (PE 0601101E, Project BLS-01) as well as advances in biointerfaces, structural and smart materials, microelectronics and MEMS, and information sciences.

(U) Program Plans:

- Demonstrate the ability to implement brain/neural control with sensory feedback in a control architecture that combines the kinetics and mechanics (degrees of freedom) of natural movement, including the realization of proprioception and reflex activity.
- Develop and demonstrate new materials, microprocessors, sensors and actuators that are both biocompatible and emulate form, function and response of natural biological limbs.
- Develop and demonstrate new distributed power sources that greatly improve the longevity of limb operation.
- Develop and demonstrate new approaches to limb healing and prosthetic integration that will dramatically decrease healing time and alleviate the discomfort of wearing prosthetic devices.
- Demonstrate a neurally controlled prosthetic limb that has the full functionality of a natural limb and transition to Walter Reed Medical Center.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Biodemilitarization of Munitions	0.000	0.000	2.880	4.274

(U) Based on results from the External Protection Program in PE 0602383E, Project BW-01, the Biodemilitarization of Munitions program will develop a system for rapid, safe, and effective inactivation of explosive munitions stockpiles in place. If these stockpiles can be removed, the raw materials for constructing explosive IEDs will be greatly reduced. Chemical and biological technologies and control processes will be developed that will rapidly perforate munition casings and alter the explosive fill. The perforation and explosive alteration technologies will be integrated into a fieldable system and tested against munitions stockpiles.

(U) Program Plans:

- Investigate technologies, for rapidly perforating diverse types of munitions casings.
- Investigate technologies for rapidly inactivating diverse types of explosive fill.
- Develop mathematical models that describe the perforation and inactivation technologies.
- Integrate technologies into a prototype system.
- Test system against explosive munitions with 155 mm projectiles.
- Develop prototype fieldable system.
- Test system against munitions stockpiles.

	FY 2006	FY 2007	FY 2008	FY 2009
Bio-Fabrication (B-FAB)	2.000	2.000	0.000	0.000

(U) The Bio-Fabrication (B-FAB) program will demonstrate the feasibility of using biochemical processes as a new nanofabrication toolset to synthesize and manufacture chemicals, materials, and devices of high value to the DoD. Such approaches would be useful as part of the nanostructure for highly efficient solar cells. Other targets for demonstration within this program include scalable technologies for opto-electronic materials and devices, mechanical materials, and site-directed-synthesis.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Materials & Biological Technology PE 0602715E, Project MBT-02	

- (U) Program Plans:
- Develop bioenabled routes for the fabrication of relevant electronic, optical, or structural materials.
  - Demonstrate the essential capacity for the fabrication of the materials at the scale of interest (2-20nm range control).
  - Develop computational, fabrication, and process control tools for the design, manipulation, and optimization of the bioprocess or bio-pathway with the target properties necessary for the fine-scale manipulation of bio-fabrication.
  - Develop and demonstrate the capability to produce bio-fabricated materials with chemically and/or spatially modulated properties, possibly including controlled doping (n-type, p-type), stacked nano-layers, quantum dots, or 3-D articulated structures in a candidate electronic, optical, or mechanical device material.
  - Demonstrate the integrability of bio-fabrication processes with current fabrication and/or micro-fabrication toolsets.
  - Design, develop, and demonstrate integrated bio fabricated electronic, optical, or mechanical devices with improved or otherwise unattainable performance or cost characteristics.
- (U) **Other Program Funding Summary Cost:**
- Not Applicable.

UNCLASSIFIED

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 17  
Page 24 of 24

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research				<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	220.011	239.370	213.529	219.844	232.025	249.025	250.425	260.425
Electronics Technology ELT-01	220.011	239.370	213.529	219.844	232.025	249.025	250.425	260.425

**(U) Mission Description:**

(U) This program element is budgeted in the Applied Research budget activity because its objective is to develop electronics that make a wide range of military applications possible.

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

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

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

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:** The manipulation of electrons in digital, analog, and mixed signal circuits for sensing, processing, and communications. This thrust includes such programs as Advanced Digital Receiver, Advanced Microsystems Technology Program, Applications of Molecular Electronics (MoleApps), Clockless Logic; Energy Starved Electronics (ESE), High Frequency Wide Band Gap Semiconductor Electronics Technology, High Power Wide Band Gap Semiconductor Electronics Technology, HyperX, Metaphoric Computing, Nanowire Electronics and Optoelectronics, Quantum Information Science (QIS), Robust Integrated Power Electronics (RIPE), Submillimeter Wave Imaging FPA Technology (SWIFT), Technology Efficient Agile Mixed Signal Microsystem (TEAM), Technology for Frequency Agile Digitally Synthesized Transmitters (TFAST), Feedback-Linearized Microwave Amplifiers, Terahertz Imaging Focal-Plane Technology (TIFT), Trusted, Uncompromised Semiconductor Technology (TrUST), Co-integration of Carbon-Based rf Electronics with Silicon Technology (CrEST), Compound Semiconductor Materials On Silicon (COSMOS), Steep-subthreshold-slope Transistors for Electronics with Extremely-low Power, and Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF).
- **Photonics:** The generation, detection, and modulation of photons for imaging, communications, and sensing. This thrust encompasses the following programs: Adaptive Focal Plane Arrays (AFPA), Advanced Precision Optical Oscillator (APROPOS), Analog Optical Signal Processing (AOSP), Bio-Electronics and Photonics, Chip-to-Chip Optical Interconnects, Photonic Analog Signal Processing Engines with Reconfigurability (PhASER), Linear Photonic RF Front End Technology (PHOR-FRONT), Optical Arbitrary Waveform Generation (OAWG), Technology for Agile Coherent Optical Transmission & Signal Processing (TACOTA), Solid State Imager/Extended Range Materials/Long Wave Length High Gain Optical Sensors, Ultrabeam, Bandwidth Compression for Power Efficient Ultra-WideBand Analog-to-Digital Conversion (UWB-ADC), Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM), and Optical Antenna Based on Nanowires.
- **MicroElectroMechanical Systems (MEMS):** Exploitation of the processing tools and materials from semiconductor technology to build electro-mechanical structures at the micro- and nano-scale. The MEMS thrust encompasses: 3-D Microelectromagnetic RF Systems (3-D MERFS), Chip Scale Atomic Clock, Radioisotope Micropower Sources (RIMS), Micro Isotope Micro-Power Sources (MIPS), and Surface Enhanced Raman Scattering (SERS) - Science and Technology.

**UNCLASSIFIED**

R-1 Line Item No. 19

Page 2 of 42

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- Architectures: Exploitation of new arrangements of materials, devices, and circuits to increase performance or reduce power. Programs under this thrust include: Design Tools for 3-Dimensional Electronic Circuit Integration, Multiple Optical Non-Redundant Aperture Generalized Sensors (MONTAGE), Polymorphous Computing Architecture (PCA), Vertically Interconnected Sensor Arrays (VISA), Lidar on a Chip, and Structured ASIC Design (StASD).
- Algorithms: Exploitation of insights into mathematical constructs for data representation, process control, and discrimination routines by leveraging knowledge of Microsystem hardware operation. Programs under this thrust include: Cognitively Augmented Design for Quantum Technology (CAD-QT), Direct Analog To Target ID - Non-Linear Math for Mixed Signal Microsystems, and Reliable Efficient Scalable Computing with Unreliable Elements (RESCUE).
- Other Electronic Technology Research: National Secure Foundry Initiative; Semiconductor Nanoelectronics Research; Characterization, Reliability and Applications for 3-D Microdevices, and 3D Technology for Advance Sensor Systems.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Digital Receiver	2.200	3.000	4.000	6.000

(U) The Advanced Digital Receiver program will leverage and improve Analog to Digital Converter (ADC) technology to develop Digital Receivers with greatly enhanced performance. Goals include reducing size, weight and power by an order of magnitude, enhancing programmability, flexibility and performance, reducing life cycle cost, and developing ADCs with 16 effective bits, 100 MHz instantaneous bandwidth and >100 dB spurious free dynamic range (SFDR).

- (U) Program Plans:
- Demonstrate 1st Pass Sigma-delta Modulator in test fixture.
  - Demonstrate 2nd Pass Sigma-delta Modulator in test fixture with ADC-Digital-to-Analog Converter (DAC) Iteration 1.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- Demonstrate Real-time Digital Receiver Operation by Benchtop Integration of Best Sigma-delta Test Fixture and Wideband Agile Receiver Decoder Test Fixture.
- Demonstrate 3rd Pass Sigma-delta Modulator in test fixture with ADC-DAC Iteration 2.
- Demonstrate Real-time Digital Receiver Module Prototype (provide 5 modules).
- Direct RF sampling strategies for 1-20 GHz input range.
- Correct nonlinear errors of full operational bands.
- Devise and Optimize Silicon Germanium (SiGe)/Complementary Metal-Oxide Semiconductor (CMOS) Monolithic RF Noise Shaping Modulator.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Microsystems Technology Program	5.000	5.000	0.000	0.000

(U) This program will explore a range of advanced microsystem concepts well beyond existing current technologies. The program will focus on technologies that exploit three-dimensional structures, new materials for Gieger mode detectors, advance patterning, and extreme scaling in silicon devices. Insights derived in these areas will be exploited in future program initiatives.

(U) Program Plans:

- Establish and exercise multi-project wafer runs for 3D integrated circuits.
- Demonstrate bonding and functionality of Silicon-On-Insulator circuits to Indium Phosphide detectors.
- Extend maskless multiple exposure system to 2x smaller features.
- Demonstrate photoresist capable of multiple in-situ exposure with enhanced resolution.
- Demonstrate sub-35 nm half-pitch interometric liquid exposure capability.
- Prepare report analyzing prospects for beyond roadmap technologies.
- Deliver data on ultra-low voltage operation of Silicon CMOS for DoD applications.

**UNCLASSIFIED**

R-1 Line Item No. 19

Page 4 of 42

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Applications of Molecular Electronics (MoleApps)	8.710	6.410	10.110	10.345

(U) The goal of the MoleApps program is to extend the capabilities being developed in the current Moletronics program to demonstrate the computational processing capabilities of molecular electronics in a system that integrates memory with control logic and data paths. A demonstration processor will be designed and built that can interpret a simple high-level language. This approach will allow the use of simpler processor designs to demonstrate the advantages of nano-scale molecular electronics that do not have the conventional circuitry overhead associated with modern pipeline chip designs.

(U) Program Plans:

- Construct combinatorial logic functions assembled from molecular-scale components.
- Use small-scale integration (SSI) to build combinatorial logic functions using molecular-scale components.
- Construct a sequential logic/finite-state machine assembled from molecular-scale components.
- Add registers or latches in communication with combinatorial logic arithmetic functions.
- Use medium-scale integration (MSI) to construct sequential logic/finite-state machine assembled from molecular-scale components.
- Demonstrate molecular electronics sensor array with 50 sensors per square micron capable of detecting 7 agents in 10 seconds with probability of detection > 0.99 and false positive <math>10^{-5}</math>.
- Develop new mathematical theories to allow the construction of new circuit devices that are more efficient, economical, user-friendly, and which meet the physical constraints and computational needs.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Clockless Logic	3.700	1.500	0.000	0.000

(U) The goal of the Clockless Logic program is to develop techniques to reduce the amount of design resources required in chip design and significantly reduce the power and noise to provide improved system operation. Clockless methods will provide more efficient designs especially for military systems with demanding space, weight, power, and noise constraints.

(U) Program Plans:

- Developed method for design of complex chips using clockless logic.
- Enhanced tools and methods for design of clockless logic circuits and systems.
- Identified and designed complex chips with significant potential for improved system performance and reduced design times.
- Applied clockless design methods to programmable logic devices to provide significant potential for improved system performance and reduced design times.
- Demonstrate performance enhancements of complex chip enabled by clockless logic in radar or similar testbed.

	FY 2006	FY 2007	FY 2008	FY 2009
Energy Starved Electronics (ESE)	2.450	3.000	0.000	0.000

(U) The Energy Starved Electronics (ESE) program seeks to develop ultra low power integrated circuit devices and circuit design methods for military electronics that must operate where power is severely limited. The objective of the program is to mature both device technology and design techniques to allow operation of devices in the sub threshold (very low voltage) regime beyond where the circuit devices normally operate. The ability to operate an ultra-low power circuit while still maintaining modest performance will enable the successful implementation of many long lived operational systems such as remote sensor networks as well as small unit communications and other wireless applications. The goal of the program will be a 100X improvement in energy per operation over conventional designs operated at low voltage.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Develop a robust design methodology and sub-threshold standard cell library.
  - Implement a feedback control scheme to achieve operation at the minimum energy dissipation point.
  - Demonstrate ultra-dynamic voltage scaling methodology that allows performance and energy to be traded-off over several orders of magnitude.
  - Establish fundamental limits of energy dissipation of digital circuits taking into account process variations and device impairments (e.g., leakage).

	FY 2006	FY 2007	FY 2008	FY 2009
High Frequency Wide Band Gap Semiconductor Electronics Technology	29.289	30.711	30.150	31.020

(U) The High Frequency Wide Band Gap Semiconductor Electronics Technology program is developing high performance, cost effective high power electronic devices that exploit the unique properties of wide band gap semiconductors. Specifically, this program will develop low defect epitaxial films, high yield fabrication processes, and device structures for integrated electronic devices for emitting and detecting high power radio frequency/microwave radiation, and high power delivery and control.

- (U) Program Plans:
- Develop bulk and surface process technologies for reducing or mitigating crystallographic defects in wide band gap materials.
  - Develop semi-insulating substrates for high frequency devices.
  - Design high power enclosures for microwave electronic assemblies.
  - Demonstrate large periphery high power devices suitable for microwave and mm-wave operation.
  - Demonstrate process reproducibility and minimization of yield limiting factors.
  - Establish device characterization for very high power solid-state amplifiers.
  - Demonstrate 100 mm Silicon Carbide (SiC) and wide band gap alternate substrates with less than 80 micropipe/cm<sup>2</sup> and resistivity 10<sup>6</sup> ohms-cm.
  - Demonstrate epitaxial processes that yield + 3 percent uniformity over 75 mm wide bandgap substrates.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E	

- Initiate thermal management study to determine best packaging approach for high power, high frequency microwave and millimeter wave transistors.
- Demonstrate 100 mm SiC and wide band gap alternate substrates with less than 40 micropipe/cm<sup>2</sup> and resistivity 10<sup>7</sup> ohms-cm.
- Demonstrate epitaxial processes that yield + 1 percent uniformity over 100 mm wide bandgap substrates.
- Identify fabrication processes for robust microwave and mm-wave devices.
- Identify thermal management concepts to sustain more than 1 KW/cm<sup>2</sup> power density in high power devices.
- Optimize wide band gap semiconductor materials to achieve 100 mm substrates with less than 10 micropipe/cm<sup>2</sup> and resistivity greater than 10<sup>7</sup> ohms-cm at room temperature.
- Demonstrate fabrication processes for robust microwave and mm-wave devices with RF yields greater than 70 percent.
- Demonstrate thermal management concepts to sustain more than 1KW/cm<sup>2</sup> power density in high power device.

	FY 2006	FY 2007	FY 2008	FY 2009
High Power Wide Band Gap Semiconductor Electronics Technology	6.705	5.500	0.000	0.000

(U) An initiative in High Power Wide Band Gap Semiconductor Electronics Technology will develop components and electronic integration technologies for high power, high frequency microsystem applications based on wide band gap semiconductors.

(U) Program Plans:

- Developed low defect conducting Silicon Carbide (SiC) substrate consistent with yielding 1 cm<sup>2</sup> devices.
- Developed lightly doped, thick (more than 100 micron) SiC epitaxy with low defects to enable 10 kV class power devices.
- Developed low on-state resistance SiC diodes capable of blocking 10 kV.
- Demonstrated SiC wafer and thick epitaxy with less than 1.5 catastrophic defects per cm<sup>2</sup> consistent with 10 kV reverse blocking.
- Initiated work on Megawatt class SiC power device able to switch at more then 100 kHz.
- Initiated work on packaging of high power density, high temperature SiC power electronics.
- Demonstrate megawatt Class SiC power devices.
- Demonstrate high power density packaging for greater than 10 kV operations.

**UNCLASSIFIED**

R-1 Line Item No. 19

Page 8 of 42

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- Develop integrated power control logic compatible with high temperature and power SiC power devices.

	FY 2006	FY 2007	FY 2008	FY 2009
HyperX	4.150	0.000	0.000	0.000

(U) Many Department of Defense (DoD) systems require processing and analysis of vast amounts of high-dimensional data in the field. The HyperX program provided the capability for high performance signal processing at significantly lower power in a reconfigurable architecture. The focus of the program was to provide the military with a reconfigurable integrated circuit technology that can achieve high performance application-specific real-time signal processing at low enough power to be suitable for embedded applications. In these cases, where severe constraints on power preclude the use of general purpose processing solutions, HyperX chips will provide more than an order of magnitude (10x) increase in both power and throughput performance over the current state-of-the-art reconfigurable Field Programmable Gate Array (FPGA) and general programmable processors.

- (U) Program Plans:
- Demonstrated a novel, reconfigurable integrated circuit (IC) with significant improvement over current programmable and reconfigurable IC technology.
  - Verified performance of HyperX IC fabric (operate at  $\geq 500$ MHz and consume  $\leq 250$ milliwatts).
  - Developed Integrated Hardware/Software Design Environment Software.

	FY 2006	FY 2007	FY 2008	FY 2009
Metaphoric Computing	0.000	4.000	4.000	8.000

(U) Metaphoric computing is a dramatically different approach to computation than the predominant paradigm using digital representation and Complementary Metal-Oxide Semiconductor (CMOS) digital circuits consisting of logic gates. The conventional digital computing systems work by employing binary data representation and mapping the physics of CMOS transistors on the lowest level computation, namely the logic gate.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E	

Metaphoric computing exploits the physics of electronic and photonic systems to enable implementation of complex signal processing algorithms in real time on power-limited platforms. Similarly, modeling and simulations of nonlinear dynamical systems will be accelerated by many orders of magnitude by employing a physics-based approach to computation entailed in metaphoric computing initiative.

- (U) Program Plans:
- Design photonic systems to display sophisticated dynamic behavior that is described by nonlinear partial differential equations.
  - Transform equations to another set of equations that describe the spread of disease or turbulent fluid flow around a complex structure.
  - Generate and manipulate asynchronous pulse train that is used to represent incoming signals over a wide dynamic range.
  - Implement signal processing operation of Independent Component Analysis that is useful in blind signal separation problems.

	FY 2006	FY 2007	FY 2008	FY 2009
Nanowire Electronics and Optoelectronics	0.000	3.000	3.000	8.000

(U) The Nanowire Electronics and Optoelectronics program will synthesize, characterize, and apply new nanowire technologies for electronic, optoelectronic, and sensor applications, which will enable new types of high-performance, heterogeneous micro- and nanosystems. Additional new types of optoelectronic devices, interconnections, and nanodisplays are also envisioned. Nanowire cell probes capable of reporting intracellular transport processes may open a new type of *in vivo* cellular biosensing for the early detection of BW agent exposure. The program goal is to extend successful nanowire materials synthesis concepts on Silicon substrates into new micro- and nanosystems applications.

- (U) Program Plans:
- Achieve controlled materials synthesis, patterning, and control of interface properties.
  - Use low-temperature vapor-liquid-solid (VLS) growth of Gallium Arsenide on a lattice-mismatched Silicon substrate.
  - Use nanodot nucleation surfaces to initiate vertical nanowire growth.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Quantum Information Science (QIS)	22.730	16.040	9.000	7.022

(U) The Quantum Information Science (QIS) program, formerly called the Quantum Entanglement Science and Technology (QuEST) program, will explore all facets of the research necessary to create new technologies based on quantum information science. Research in this area has the ultimate goal of demonstrating the potentially significant advantages of quantum mechanical effects in communication and computing. Expected applications include: new improved forms of highly secure communication; faster algorithms for optimization in logistics and wargaming; highly precise measurements of time and position on the earth and in space; and new image and signal processing methods for target tracking. Technical challenges include: loss of information due to quantum decoherence; limited communication distance due to signal attenuation; limited selection of algorithms and protocols; and larger numbers of bits. Error correction codes, fault tolerant schemes, and longer decoherence times will address the loss of information. Signal attenuation will be overcome by exploiting quantum repeaters. New algorithm techniques and complexity analysis will increase the selection of algorithms, as will a focus on signal processing. The QIS program is a broad-based effort that will continue to explore the fundamental open questions, the discovery of novel algorithms, and the theoretical and experimental limitations of quantum processing as well as the construction of efficient implementations.

(U) Program Plans:

- Refine quantum architecture and design solutions for problems such as graph isomorphism, imaging, and signal processing.
- Investigate alternative protocols for secure quantum communication, quantum complexity, and control.
- Integrate improved single and entangled photon sources and detectors into existing quantum communication networks.
- Investigate alternative designs, architectures and devices for quantum communication and demonstrate high-rate (1Gbit/sec) quantum-secure communication over a single link; transition quantum-secure communication to existing DoD mobile testbed.
- Investigate unresolved fundamental issues related to quantum information science.
- Employ qubit architectures to demonstrate an application of interest to the DoD (e.g., quantum repeater, secure metropolitan-area network).
- Demonstrate interoperation between multiple qubit types to interconnect quantum communications links.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Robust Integrated Power Electronics (RIPE)	5.580	8.753	4.808	0.000

(U) The RIPE program will develop new semiconductor materials, devices, and circuits that enable highly compact, highly efficient electronic power converter modules. These new modules will be capable of providing up to 50kW of power per module at a power density of 500W/cubic inch. Based on fundamental material properties, the new power modules will be capable of operating in harsh environments. These new power converters will reduce the launch weight of space-based platforms by hundreds of pounds and will enable new modes of operation where the power conversion is done at the point of load and provides high quality power to payloads. Application of RIPE on Naval surface ships would result in a significant reduction of power supply weight; allowing for additional electronic components and/or weapons.

- (U) Program Plans:
- Identified key technical challenges and quantified impact on potential platforms.
  - Perform concept study to define opportunities for smart power and the potential for integrating silicon carbide, or other wide bandgap semiconductor, with silicon electronics.
  - Select and optimize wide bandgap materials and processes for smart power circuits.
  - Develop integration techniques for silicon carbide, or other wide bandgap semiconductor, onto silicon and/or silicon onto silicon carbide.
  - Develop low on-resistance, fast switching silicon carbide power devices with hybrid control electronics.

	FY 2006	FY 2007	FY 2008	FY 2009
Submillimeter Wave Imaging FPA Technology (SWIFT)	6.850	8.168	5.260	0.000

(U) The Submillimeter Wave Imaging FPA (Focal Plane Array) Technology (SWIFT) program will develop revolutionary component and integration technologies to enable exploitation of this spectral region. A specific objective will be the development of a new class of sensors capable of low-power, video-rate, background and diffraction limited submillimeter imaging.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Develop compact, efficient, and high-power THz sources using new electronic and frequency conversion approaches.
  - Develop sensitive and large format receiver arrays, advanced integration, and backend signal processing techniques.
  - Develop and demonstrate a submillimeter focal plane imager.

	FY 2006	FY 2007	FY 2008	FY 2009
Technology Efficient, Agile Mixed Signal Microsystem (TEAM)	10.920	8.500	0.000	0.000

(U) Technology for Efficient, Agile Mixed Signal Microsystems (TEAM) will enable fabrication of high performance mixed signal systems-on-chip that will be the core of the embedded electronics in new platforms that are constrained by size and on-board power.

- (U) Program Plans:
- Develop and demonstrate nanoscale silicon-based structures and associated fabrication processes to achieve high-speed analog/RF functions.
  - Optimize device and process parameters for high speed mixed signal circuits.
  - Produce test devices for analog/RF parameter extraction.
  - Demonstrate Complementary Metal Oxide Semiconductor (CMOS) compatible fabrication processes that can yield integration levels greater than 10,000 nanoscale devices.
  - Initiate highly parallel densely interconnected architectures with micron-sized vias penetrating stacks of detectors, analog, mixed signal and digital circuits.
  - Demonstrate operation of high performance mixed signal circuits based on nanoscale devices.
  - Demonstrate low noise interface and high isolation (up to 100 db) between high performance analog circuits and associated digital signal processing.
  - Fabricate mixed signal systems on chip with nanoscale transistors.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Technology for Frequency Agile Digitally Synthesized Transmitters (TFAST)	10.000	10.120	0.000	0.000

(U) The TFAST program (Ultra High Speed Circuit Technology) will develop super-scaled Indium Phosphide (InP) Heterojunction Bipolar Transistor (HBT) technology compatible with a ten-fold increase in transistor integration for complex mixed signal circuits. Phase I established the core transistor and circuit technology to enable the demonstration of critical small scale circuit building blocks suitable for complex mixed signal circuits operating at speeds three times that currently achievable and ten times lower power. Phase II is extending the technology to the demonstration of complex (more than 20,000 transistors) mixed signal circuits with an emphasis on direct digital synthesizers for frequency agile transmitters.

(U) Program Plans:

- Develop material and process technology for super-scaled InP double heterostructure bipolar transistors (DHBTs). Technical approaches will leverage the process technology used in the silicon, and silicon germanium, industry to produce a planar, highly scalable InP HBT.
- Extend the core DHBT and interconnect technology with the implementation of complex mixed signal circuits.
- Develop super-scaled InP HBT processing technology for 0.25 micron and below.
- Develop high current, planar, InP HBTs compatible with high levels of integration.
- Develop greater than 100 GHz mixed signal circuit building blocks.
- Demonstrate record performance InP HBTs in a planar process for complex mixed signal circuits.
- Demonstrate a critical mixed signal building block circuit operating at more than 100 GHz.
- Develop circuit designs for direct digital frequency synthesizers (DDS) operating with clock speed up to 30 GHz.
- Define circuit designs and layouts for mm-wave DDS and related complex mixed signal circuits.
- Develop full circuit capability using super-scaled InP HBTs in complex (more than 20,000 transistor) circuits.
- Establish device models and critical design rules.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Feedback-Linearized Microwave Amplifiers	0.000	5.580	4.970	5.840

(U) Modern military platforms are requiring increased dynamic range receivers for their onboard communications, in both radar and electronic warfare antenna systems. The goal of this program is to develop RF amplifiers with revolutionary increased dynamic range receivers through the use of linear negative feedback. This program will develop the core technologies and components that may be used as building blocks and/or modules in future system applications. This program will leverage technologies from the TFAST program.

(U) Program Plans:

- Ensure stability of closed-looped amplifier while not increasing internal latencies from transistors and layout parasites.
- Address design challenges related to negative feedback.
- Investigate avoidance of circuit oscillation.

	FY 2006	FY 2007	FY 2008	FY 2009
Terahertz Imaging Focal-Plane Technology (TIFT)	9.326	13.000	7.000	0.000

(U) The TIFT program will demonstrate large, multi-element (> 40K pixels) detector receiver focal plane arrays that respond to radiation in the THz band (> 0.557 THz). The sensor system will be able to operate effectively at a standoff range (> 25m) with a high spatial resolution (< 2 cm) limited only by beam diffraction. The imaging receiver will produce a two-dimensional (2D) image in which each pixel records the relative intensity of the THz radiation received on the focal plane within the appropriate section of the field of view of the scene being sensed. The program will achieve intensity sensitivities as close as possible to the thermal background limit at room temperature. The minimal acceptable acquisition time is video-rate (30 Hz). The receiver may be either passive or active (including THz time domain methods). The size, weight, and electrical power requirements will be consistent with portability.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Demonstrate revolutionary component and integration technologies necessary for the development of a diffraction-limited, video-rate THz (at least  $0.557 \times 10^{12}$ Hz) frequency imager.
  - Demonstrate a compact THz source achieving at least 10 mW of average power and 1% wall plug efficiency, as required for active illumination and/or for local oscillators in heterodyne or homodyne detection schemes.
  - Demonstrate a THz receiver capable of achieving a noise equivalent power of less than  $1 \text{ pW/Hz}^{1/2}$  as measured with an integrated acquisition time of no more than 30 milliseconds and a pre-detection bandwidth of no more than 50 GHz, as required in order to achieve a system-level noise equivalent delta temperature of 1K or better.

	FY 2006	FY 2007	FY 2008	FY 2009
Trusted, Uncompromised Semiconductor Technology (TrUST)	0.000	10.000	10.000	14.000

(U) The TrUST program will explore techniques to insure Integrated Circuits (IC's) of interest to the DoD can be certified as trustworthy after fabrication. These efforts will compliment other maskless lithography and verifiable design programs. The first thrust will develop new tools and techniques for rapidly analyzing fabricated circuits and comparing the circuit topology to that of the design produced at the trusted design source. The second thrust will exploit emerging research in 3D stacked and monolithic circuits to distribute, or segment, a complex IC into smaller sub-circuits. In this way, the sub-circuits can be fabricated separately, making it more difficult to compromise the complete circuit and making it easier to characterize each circuit for trustworthiness. This approach will also leverage the performance advances projected for 3D architectures. The final thrust will explore novel ways to add "hardware jacket" to complete IC's that will service to monitor the circuits' performance and raise a flag if unspecified operations are encountered.

- (U) Program Plans:
- Develop new tools and techniques for rapidly analyzing fabricated circuits and comparing the circuit topology to that of the design produced at the trusted design source.
  - Exploit emerging research in 3D stacked and monolithic circuits to distribute, or segment, a complex Integrated Circuit (IC) into smaller sub-circuits.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- Explore novel ways to add “hardware jacket” to complete ICs that will service to monitor the circuits’ performance and raise a flag if unspecified operations are encountered.
- Develop distributed circuit architectures by building trusted circuits through 3D segmented designs.
- Explore Integrated Circuit monitoring for deployed performance verification.

	FY 2006	FY 2007	FY 2008	FY 2009
Co-integration of Carbon-Based rf Electronics with Silicon Technology (CrEST)	0.000	0.000	4.000	5.000

(U) The CrEST program seeks to develop Metal Oxide Silicon Field Effect Transistors (MOSFETs) based on the planar carbon monolayer (graphene) system. Such a system has most of the desirable properties of carbon nanotubes, but found in a planar geometry, which is much more compatible with standard Complementary Metal-Oxide Semiconductor (CMOS) processing. The 10X mobility enhancement of graphene with respect to silicon will be exploited for high performance (high current drive) and low power electronics applications. The excellent mobility is achieved in a monolayer system which is ideal from the electrostatic (i.e., gate control) point of view enabling efficient scaling to very small device geometries. Graphene FET devices are envisioned to be an enhancement, not replacement for silicon CMOS, for critical radio frequency or mixed signal circuit elements. Thus the demonstrated integration of graphene devices into standard silicon CMOS processing is a key task of this program.

- (U) Program Plans:
- Demonstrate hybrid graphene-silicon CMOS circuits for high performance and low power applications.

	FY 2006	FY 2007	FY 2008	FY 2009
Compound Semiconductor Materials On Silicon (COSMOS)	0.000	0.000	5.000	10.000

(U) The objective of the Compound Semiconductor Materials On Silicon (COSMOS) program will be to develop new methods to tightly integrate compound semiconductor technologies within silicon CMOS circuits in order to achieve such unprecedented circuit performance levels.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

Currently, heterogeneous integration of compound semiconductors with silicon is typically achieved through the use of multi-chip modules and similar assemblies. While adequate for relatively low performance applications (e.g., power amplifiers for cellular telephone handsets), the integration complexity that can be achieved in this manner is extremely limited. At the other end of the spectrum, epitaxial methods to grow III-V materials onto silicon substrates have generally proven unsatisfactory due to high defect densities, cost, and inflexibility in supporting multiple technologies. Instead, COSMOS will focus on an intermediate approach, which is likely to be the most successful strategy in terms of performance, size and cost. This will involve sub-circuit integration in which III-V materials devices are placed onto a processed CMOS wafer.

(U) Program Plans:

- Demonstrate ultralow power dissipation circuits.
- Develop methods for sub-circuit integration onto fully processed CMOS wafers.
- Evaluate alignment and bonding methods to achieve mechanical integrity of dissimilar materials, post-processing compatibility with CMOS, and the achievement of high fabrication yields. This program will greatly extend the capabilities of wide bandgap devices for use in power amplifiers (PAs) at frequencies at least as high as X-band and to make this technology useful at very high frequencies (W-band). PAPEETE will leverage advances in materials and device topologies to demonstrate large (>1 mm) devices operating in this new regime. Such high density devices will enable PAs with higher output power, fewer power combining stages, and greater efficiency than previously possible. This program will develop new means to decrease the number of optical phonons in the critical gate region of RF PA devices. Such phonon engineering should improve high power performance.

	FY 2006	FY 2007	FY 2008	FY 2009
Steep-subthreshold-slope Transistors for Electronics with Extremely-low Power	0.000	0.000	5.000	7.000

(U) The Steep-subthreshold-slope Transistors for Electronics with Extremely-low Power (STEEP) program seeks to develop field emission (tunneling) based Metal Oxide Silicon Field Effect Transistors (MOSFETs). Such devices would enable lowering supply voltages by 5X which would result in an active power savings of 25X and a standby power saving of at least 5X. Prototype circuits will be developed showing such power savings with little to no impact on performance (current drive). Such field emission devices will be integrated into standard CMOS based processing methods and offer significant CMOS power reduction with no performance penalty.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Develop novel MOSFET switch with significantly steeper sub-threshold slope.
  - Develop CMOS process integration.
  - Optimize drive current in presence of tunneling barrier.
  - Demonstrate ultra-low power, high performance prototype circuits.

	FY 2006	FY 2007	FY 2008	FY 2009
Semiconductor-Tuned HTS Filters for Ultra-Sensitive RF Receivers (SURF)	0.000	0.000	3.343	7.900

(U) The operation of frequency-hopping radios greatly interferes with co-located ultra-sensitive receivers. The situation will get worse as the “hoppers” proliferate, even interfering within the receive channels of one another. A general solution would be to use “brick-wall” front-end filters for the receivers, re-tuning at the rate of the hoppers. High-temperature superconducting (HTS) filters have been used very successfully for negating strong transmissions at nearby frequencies, and are unique in their ability to totally reject out-of-band signals without attenuation of signals in the pass-band. However, they have been used only for rejection of fixed-frequency interference. This program would increase the turning speed of HTS filters, from about a second with present mechanical methods, to microsecond speeds required for systems such as the Joint Tactical Information Distribution System (JTIDS). The technology for such a million-fold improvement will rely upon semiconductor tuning, properly mated with the superconducting filter materials. In addition to interference-rejection at microsecond speeds, these filters will make it possible to perform wide spectral searches with unprecedented frequency resolution, enabling detection of very weak emissions (signatures) characteristic of threat systems.

- (U) Program Plans:
- Develop the technology of semiconductor filters, employing either varactor tuning or switched capacitor banks, in integrated-circuit format.
  - Demonstrate semi-continuous tuning over a 10 percent bandwidth, with stepwise (switching) semiconductor retuning at microsecond speeds.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E	

- Demonstrate continuous tuning of HTS notch filters at microsecond speeds, adequately negating interference from co-located transmitters over the receive frequency band.

	FY 2006	FY 2007	FY 2008	FY 2009
Adaptive Focal Plane Arrays (AFPA)	5.170	8.039	5.870	5.275

(U) The goal of this program is to demonstrate high-performance focal plane arrays that are widely tunable across the entire infrared (IR) spectrum (including the short, middle and long-wave infrared bands), thus enabling “hyperspectral imaging on a chip.” The Adaptive Focal Plane Array (AFPA) program will also allow for broadband Forward Looking Infrared (FLIR) imaging with high spatial resolution. These AFPAs will be electrically tunable on a pixel-by-pixel basis, thus enabling the real-time reconfiguration of the array to maximize either spectral coverage or spatial resolution. The AFPAs will not simply be multi-functional, but rather will be adaptable by means of electronic control at each pixel. Thus, the AFPAs will serve as an intelligent front-end to an optoelectronic microsystem. The AFPA program outcome will be a large format focal plane array that provides the best of both FLIR and Hyper-Spectral Imaging (HSI).

- (U) Program Plans:
- Develop component technology (tunable IR photodetectors).
  - Integrate detector array.
  - Demonstrate pixel-by-pixel electrical tunability in IR.
  - Demonstrate AFPA prototype field using a large format array.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Precision Optical Oscillator (APROPOS)	6.614	6.020	4.200	0.000

(U) The APROPOS program will leverage advances in materials and lasers to develop new precision microwave-stable local oscillators with extremely low phase noise (up to 50 dB better than the current state of the art) at small offsets from microwave carrier frequencies. This capability

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

will enhance performance of radars in the detection of slow moving targets; electronic warfare systems in the identification of specific emitters and communication systems in weak signal detection and clutter suppression all at increased standoff range.

- (U) Program Plans:
- Improve phase noise power spectral density by 25 dB and prove the utility of multi-line laser cavities and opto-electronic oscillators.
  - Identify and characterize environmental susceptibilities and define path to 50 dB improvement over state-of-the-art.
  - Demonstrate 50 dB improvements in lab setting.
  - Develop miniaturization approach and packing concept to mitigate environmental susceptibilities.
  - Miniaturize devices in ruggedized packages.
  - Demonstrate performance in tactical environments by inserting laser cavities or oscillators in system testbeds.

	FY 2006	FY 2007	FY 2008	FY 2009
Analog Optical Signal Processing (AOSP)	3.989	0.000	0.000	0.000

(U) Analog Optical Signal Processing (AOSP) significantly enhanced the performance and enabled new capabilities and architectures for tactical and strategic RF systems. The program expanded the dynamic range-bandwidth and time-bandwidth limits by a factor of 1,000 through the introduction of analog optical signal processing components into the system front ends.

- (U) Program Plans:
- Designed, fabricated and tested individual photonic components capable of meeting RF signal processing requirements.
  - Determined the most promising approaches for development of integrated, chip-scale components using new materials and processing technologies.
  - Down-selected the most promising approaches and completed prototype module assembly.
  - Constructed testbeds capable of fully characterizing the photonic-based RF signal processing components.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Bio-Electronics and Photonics	0.000	4.000	5.000	5.000

(U) The Bio-Electronics and Photonics program will demonstrate new capabilities in protein- and DNA-based optical and electronic media that will address the challenge of high density storage without loss of rapid access time.

(U) Program Plans:

- Develop new synthetic or engineered natural chromophores that possess both sufficient chromophore density and optical cross-section.
- Use DNA as a low loss cladding layer for electro-optic (EO) devices, i.e., waveguides.
- Demonstrate sub-wavelength addressing techniques.
- Demonstrate high density, rapid access logic gates and memories.

	FY 2006	FY 2007	FY 2008	FY 2009
Chip-to-Chip Optical Interconnects	4.709	1.000	0.000	0.000

(U) Continuing advances in integrated circuits technology are expected to push the clock rates of Complimentary Metal Oxide Semiconductor (CMOS) chips into 10GHz range over the next five-to-seven years. At the same time, copper-based technologies for implementing large number of high speed channels for routing these signals on a printed circuit board and back planes are expected to run into fundamental difficulties. This performance gap in the on-chip and between-chip interconnection technology will create data throughput bottlenecks affecting military-critical sensor signal processing systems. To address this pressing issue, this program will develop optical technology for implementing chip-to chip interconnects at the board and back plane level.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Develop high-linear density, low loss optical data transport channels that can be routed to ~1 meter distance in a geometric form factor compatible with a printed circuit board.
  - Demonstrate high speed (faster than 10 GBps), low power (less than 50 mW) optical transmitters/receivers.
  - Integrate optical transmitters/receivers and optical data paths with electronic packaging and manufacturing approaches.

	FY 2006	FY 2007	FY 2008	FY 2009
Photonic Analog Signal Processing Engines with Reconfigurability (PhASER)	0.000	0.000	5.000	8.000

(U) The goal of the Photonic Analog Signal Processing Engines with Reconfigurability (PhASER) program is the creation of new Photonic Integrated Circuit (PIC) elements, and associated programmable filter array concepts that will enable high-throughput, low-power signal processors. The focus is on the development of novel "Unit Cells," which may be used as building blocks to synthesize arbitrarily complex filters within a PIC platform for ultra-high bandwidth signal processing applications.

- (U) Program Plans:
- Define and design a novel analog photonic "Unit Cell," which is nominally comprised of a sub-array of waveguide-connected programmable active elements. The Unit Cell should be externally linkable with integrated waveguides, which will allow it to function as a building block in programmable PIC arrays for generalized high-order finite impulse response/infinite impulse response (FIR/IIR) filters.
  - Demonstrate an experimental Unit Cell concept.
  - Determine how the Unit Cell, when arrayed within a high-density PIC, will perform. Develop a filter synthesis tool to demonstrate how Unit Cells will enable generalized high-order filters, and how they will be programmed and tested at the chip-level to ensure high yield.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Linear Photonic RF Front End Technology (PHOR-FRONT)	0.000	4.594	5.385	5.000

(U) The goal of this program is to develop photonic transmitter modules that can adapt their frequency response and dynamic range characteristics to mate with the full spectrum of narrow-band and broadband microwave transmission applications covering the 2 MHz – 20 GHz range. These field programmable, real-time adaptive photonic interface modules will find application in high dynamic range communications, radar and Electronic Warfare (EW) antenna applications.

(U) Program Plans:

- Develop photonic transmitter modules to allow tunable frequency and impedance matching to arbitrary antenna structures with adaptive pre-distortion, feedback and feed-forward linearization schemes.
- Transition into airborne, space and maritime platforms where wideband communications, radar and EW apertures with size, weight and power advantages are needed.

	FY 2006	FY 2007	FY 2008	FY 2009
Optical Arbitrary Waveform Generation (OAWG)	6.735	9.482	7.414	4.000

(U) The ultimate vision for the Optical Arbitrary Waveform Generator (OAWG) program is to demonstrate a compact, robust, practical, stable octave-spanning optical oscillator, integrated with an encoder/decoder capable of addressing individual frequency components with an update rate equal to the mode-locked repetition rate. This would provide an unprecedented level of performance for optical systems, and enable numerous high level applications including sub-diffraction-limited imaging and ultra-wideband optical communications.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Demonstrate technology for producing (and detecting) arbitrary coherent optical waveforms with > with positive linear chirp of 1000 GHz with fidelity of <5% least-squared deviation from mathematical ideal waveform, accounting for interference from adjacent waveforms.
  - Demonstrate production of single-cycle, 3 GHz square wave (pulse train duration of 0.67 ns) with fidelity of <1% least-squared deviation from mathematical ideal waveform.

	FY 2006	FY 2007	FY 2008	FY 2009
Technology for Agile Coherent Optical Transmission & Signal Processing (TACOTA)	4.995	6.705	5.700	0.000

(U) The goal of TACOTA (formerly called Optoelectronics for Coherent Optical Transmission and Signal Processing) is to develop optoelectronic component technologies that enable increased physical layer security in optical transmission systems through the synergistic use of coherent optical technologies and high-speed electronics. Secure, high-capacity free-space communications is essential for the transformational communications architecture to be realized. Both digital and analog transmission will be considered.

- (U) Program Plans:
- Develop compact stable lasers, local oscillators and frequency combs (<10 Hz linewidths with <1 kHz long-term accuracy), high-speed quadrature optical modulators (>6 bit/s/Hz spectral efficiency with 100 GHz signaling rates), and digital homodyne receivers.
  - Transition into airborne, space and maritime platforms where secure, high-capacity military optical networks for targeting and imaging are coveted.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Solid State Imager/Extended Range Materials/Long WL High Grain Optical Sensors	2.000	3.000	0.000	0.000

(U) Imaging in the near-to-mid Wave Length (WL) spectral region provides the capability to penetrate atmospheric obscurants, where conventional sensors cease to generate data or produce severely degraded information. New materials and concepts for solid state imaging are essential to take advantage of this novel imaging regime, providing the capability to see where others cannot. This development includes new material concepts, such as quantum dots and superlattice structures, which offer the ability to precisely tailor the spectral band, and potentially operate at or near room temperature. In addition, new solid state sensor concepts will be developed to spatially and temporally co-register each pixel in the image to implement novel on-chip processing for noise cancellation and clutter rejection in severely degraded environments.

- (U) Program Plans:
- Develop new material concepts.
  - Develop new solid state sensors concepts.

	FY 2006	FY 2007	FY 2008	FY 2009
Ultrabeam	1.344	1.000	0.000	0.000

(U) The Ultrabeam program involves conversion of femtosecond duration ultraviolet laser light pulses to x-rays and the study of intense x-ray pulse propagation in various media.

- (U) Program Plans:
- Validate the scientific feasibility of the conversion and propagation processes.
  - Demonstrate a working laboratory model involving higher beam energies and shorter pulse durations.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Ultra-WideBand A/D Conversion (UWB-ADC)	0.000	0.000	5.235	7.445

(U) The objective of UWB-ADC is to develop revolutionary technologies to enable Analog to Digital Converters (ADCs) with high-resolution and large instantaneous bandwidth while maintaining power consumption that is commensurate with user community requirements. It is expected that such ADCs would have a dramatic impact on SIGINT capabilities such as direct down conversion of UHF through X-band RF signals. Furthermore, ADCs enabled by UWB-ADC alleviate the current ADC bottleneck in high capacity digital RF communications links by enabling more spectrally efficient wideband waveforms. This program aims to develop a bandwidth-compressing photonic front end that provides a force multiplier for any available back-end electronic ADCs.

- (U) Program Plans:
- Emphasize photonic time-stretch analog-to-digital converter (TS-ADC) technology.
  - Develop multi-channel time stretching technologies for continuous time signals.
  - Develop components mandated by system-level ADC specifications.

	FY 2006	FY 2007	FY 2008	FY 2009
Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM)	0.000	0.000	3.750	6.000

(U) The goal of the Novel Technologies for Optoelectronics Materials Manufacturing (NTOMM) program is to develop and demonstrate new technologies for Group II-VI (e.g., Cadmium Selenide (CdSe)) and III-V (e.g., Gallium Nitride (GaN)) materials and device manufacturing, enabling imaging and emissive device fabrication at 1% to 10% current costs. This advance will dramatically expand the application space of such devices, enabling lower cost per large area IR imaging systems, non-planar devices and systems, and thin film and flexible devices and systems. This program will demonstrate IR detectors and imagers, Light Emitting Diodes, and solid state lasers fabricated via new methods, and include a rapid demonstration of at least 5x reduction in yielded device cost. The NTOMM program will leverage recent and ongoing developments in

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E	

nano-material synthesis and assembly, which have demonstrated the potential for over 50% precursor stream usage in the fabrication of II-VI and III-V materials.

(U) Program Plans:

- Develop synthesis methods that improve quality and monodispersity (characterized by particles of uniform size in a dispersed space) of InN and InGaN nanocrystals.
- Develop cost effective synthesis methods for Group II-VI and III-V materials.
- Utilize controlled arrays of InGaN to form high efficiency Light Emitting Diode (LED) structures and imaging sensors in IR.
- Assemble layer-by-layer heterostructures (characterized by dissimilar materials with non-equal band gaps) from ordered planar arrays of nanocrystals.
- Develop and demonstrate techniques for layer doping of heterostructure materials.

	FY 2006	FY 2007	FY 2008	FY 2009
Optical Antenna Based on Nanowires	0.000	0.000	2.000	4.000

(U) In optics, nanotechnology research will develop the ability to create structures of the same scale as incident light wavelengths. These structures can interact with and affect the incident light. This program will create nano-meter scale structures, which will act as optical antenna arrays that can respond coherently to electromagnetic fields at optical wavelengths. Each array element would be a nanostructure, such as a nanotube or nanowire, and provide a way to measure directly the field magnitude and phase in both space and time. A system based on this technology would potentially be smaller, lighter in weight, and able to move from the sub-optimal method of intensity-only measurements into the information-rich domain of complex imaging.

(U) Program Plans:

- Develop and demonstrate small element count two-dimensional array, characterize performance and scaling relationships.
- Demonstrate and characterize ability to measure the magnitude and phase of the incident light.
- Demonstrate image formation capability.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- Design, develop, and test a prototype system.

	FY 2006	FY 2007	FY 2008	FY 2009
3-D Microelectromagnetic RF Systems (3-D MERFS)	5.804	3.960	1.750	1.000

(U) The 3-D Microelectromagnetic RF systems (3-D MERFS) program will develop complete millimeter wave (MMW) active arrays on a single or a very small number of wafers. The program will exploit new technologies being developed commercially that allow Gallium Arsenide (GaAs) active components to be placed on Silicon wafers, and advances in Indium Phosphide and Silicon Germanium that may allow an entire MMW Electronically Scanned Array (ESA) to become very highly integrated on a sandwich of wafers. At lower frequencies, the large spacing between radiating elements precludes the efficient use of the wafer real estate for fabricating the entire ESA, but at Ka and W- bands, the element spacing is small enough to allow an ESA to be made with active transmit/receive chips and control circuits on one layer, radiators on another, and a feed system on a third. This could potentially make them very cheap, compact, lightweight and reliable. This would enable the development of new MMW ESAs of a six inch diameter or less for seekers, communication arrays for point-to-point communications, sensors for smart munitions, robotics and small remotely piloted vehicles. This program will build upon technology developed under the Vertically Interconnected Sensor Array program.

(U) Program Plans:

- Survey the emerging commercial MMW technology base and identify the best candidate processes for the MMW ESA application.
- Develop the optimal ESA architectures for wafer fabrication.
- Determine requirements for MMW ESAs that match the expected performance.
- Design, build, and test candidate ESA designs.
- Design, build, and test full ESA seeker or other system using the wafer fabrication technology.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Chip Scale Atomic Clock	4.023	5.000	8.000	8.000

(U) The Chip Scale Atomic Clock will demonstrate a low-power chip scale atomic-resonance-based time-reference unit with stability better than one part per billion in one second. Application examples of this program will include the time reference unit used for GPS signal locking.

(U) Program Plans:

- Demonstrate feasibility and theoretical limits of miniaturization of cesium clock.
- Demonstrate subcomponent fabrication including atomic chamber, excitation and detection function.
- Demonstrate design and fabrication innovation for atomic-confinement cell and for GHz resonators suitable for phase locking or direct coupling with atomic confinement cell.

	FY 2006	FY 2007	FY 2008	FY 2009
Radioisotope Micropower Sources (RIMS)	2.056	2.289	3.021	0.997

(U) This effort will seek to develop the technologies and system concepts required for safely producing electrical power from radioisotope materials for portable and mobile applications, using materials that can provide passive power generation. There will also be research in compact radioisotope battery approaches that harness MEMS technology to safely and efficiently convert radioisotope energy to either electrical or mechanical power while avoiding lifetime-limiting damage to the power converter caused by highly energetic particles (e.g., such as often seen in previous semiconductor approaches to energy conversion). The goal is to provide electrical power to macro-scale systems such as munitions, unattended sensors, and weapon systems, RF ID tags, and other applications requiring relatively low (up to tens of milliwatts) average power. This program formerly funded the Micro Isotope Micro-Power Sources (MIPS) program, which has been broken out as a separate program and separately described in this exhibit.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Developed and demonstrated core technologies of radioisotopes and the manufacturing of alpha and beta capture mechanisms.
  - Develop large-scale radioisotope generation cell based on alpha and beta particle capture.
  - Demonstrate advances in power output at high conversion factors, material stability, and particle capture in a small form factor with high conversion efficiencies, while operating within safety considerations and limitations.
  - Demonstrate reasonable longevity for the chosen radioisotope-to-electrical or radioisotope-to-mechanical power conversion technique.
  - Demonstrate actual, long-lasting power generation by the chosen radioisotope-to-electrical or radioisotope-to-mechanical conversion method.

	FY 2006	FY 2007	FY 2008	FY 2009
Micro Isotope Micro-Power Sources (MIPS)	1.650	2.375	4.000	5.000

(U) The goal of the MIPS program is to demonstrate safe, affordable micro isotope power sources able to outperform conventional batteries in terms of energy and/or power density, and provide long lasting milliwatt (mW)-level power for an array of critical military applications, such as unattended sensors, perimeter defense, detection of weapons of mass destruction (WMD), and environmental protection.

- (U) Program Plans:
- Evaluate the applicability of known and potential sources to critical applications faced by the department. Analyze the feasibility and cost of manufacturing for these sources and compare against benefit derived for each application.
  - Investigate a range of approaches to achieving compact, milliwatt-level power sources including alphavoltaic, betavoltaic, and thermoelectric strategies.
  - Demonstrate power conversion devices able to meet relevant size, power, and safety constraints for potential applications.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Surface Enhanced Raman Scattering (SERS) - Science and Technology	0.000	0.000	5.000	8.000

(U) Surface Enhanced Raman Scattering (SERS) – Science and Technology program focuses on the fundamental technical challenges facing potential sensor performance with respect to their sensitivity, selectivity, enhancement factors and development. SERS nanoparticles have considerable potential for both chemical and biochemical sensing applications due to: (1) their potential large spectral enhancement factors, (2) the nature of spectral fingerprints that can be expected to yield low false alarm rates, and (3) the capability for detecting targeted molecules at useful standoff ranges. This program seeks to identify and overcome the key scientific and technical challenges necessary for replacing existing sensors of chemical and biological warfare (CBW) agents with SERS-based sensing approaches.

- (U) Program Plans:
- Develop understanding of nanoparticle shape and its effect on SERS enhancements; examine high quality resonators for SERS applications.
  - Develop methods to engineer nanoparticles with 1 nanometer feature sizes (separation) on a macroscale.

	FY 2006	FY 2007	FY 2008	FY 2009
Design Tools for 3-Dimensional Electronic Circuit Integration	13.634	10.272	7.474	0.000

(U) This program will develop a new generation of Computer Aided Design (CAD) tools to enable the design of integrated three-dimensional electronic circuits. The program will focus on methodologies to analyze and assess coupled electrical and thermal performance of electronic circuits and tools for the coupled optimization of parameters such as integration density, cross talk, interconnect latency and thermal management. The goals of this initiative are to develop a robust 3-D circuit technology through the development of advanced process capabilities and the design tools needed to fully exploit a true 3-D technology for producing high performance circuits. The deliverables from this program will have a significant impact on the design of mixed signal (digital/analog/RF) systems and Systems-on-a-Chip for high performance sensing, communications, and processing systems for future military requirements.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Apply 3D design tools to test structure.
  - Fabricate and test structures.
  - Verify models against data.

	FY 2006	FY 2007	FY 2008	FY 2009
Multiple Optical Non-Redundant Aperture Generalized Sensors (MONTAGE)	4.070	3.248	0.000	0.000

(U) The MONTAGE program will implement a revolutionary change in the design principles for imaging sensor systems, enabling radical transformation of the form, fit, and function of these systems for a wide variety of high-value DoD applications. Significant improvements in the performance, affordability, and deployability of imaging sensor systems will be obtained through rational co-design and joint optimization of the imaging optics, the photo sensor array and the post-processing algorithms. By reaching well beyond conventional designs, MONTAGE sensors will realize optimal distribution of information handling functions between analog optics and digital post-detection processing.

(U) Specific demonstrations include reduction of the depth/thickness of an imaging sensor by an order of magnitude without compromising its light gathering ability or resolution. This dramatic reduction in thickness will then allow the imaging sensors to be deployed conformally around a curved surface of a platform (e.g., UAV, tank, or helmet). Furthermore, the flexibility generated by the incorporation of post-processing in the image formation will allow variable resolution image formation, which in turn reduces the data load for subsequent image exploitation and communication systems. Advanced post-processing algorithms will support video operation at frame rates in excess of 10 frames per second using standard computing platforms.

- (U) Program Plans:
- Develop novel optical designs allowing depth reduction by 10X.
  - Concurrent with optics design, develop sensor array design and post-processing algorithms to realize signal-to-noise ratio and resolution of comparable optical aperture.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- Demonstrate ability to allocate highest spatial resolution to specified regions of interest in the image while maintaining medium resolution elsewhere.
- Develop architectures for surpassing detector size-limited resolution and potentially exceed optically limited resolution.
- Demonstrate operation of a thin imaging system deployed on a curved surface.
- Demonstrate real time performance of thin imaging systems in representative DoD applications with performance evaluated using application-specific metrics for image quality, sensor cost, power consumption, mechanical properties.

	FY 2006	FY 2007	FY 2008	FY 2009
Polymorphous Computing Architecture (PCA)	11.392	5.802	8.000	14.000

(U) The Polymorphous Computing Architectures (PCA) program is developing a revolutionary approach to the implementation of embedded computing systems to support reactive multi-mission, multi-sensor, and in-flight retargetable missions. This revolutionary approach will reduce payload adaptation, optimization and verification processes from years to minutes. The program breaks the current development approach of hardware first and software last by moving beyond conventional silicon to flexible polymorphous computing systems. The key efforts of this revolutionary step forward in embedded computing systems are: (1) define critical reactive computing requirements and critical micro-architectural features; (2) explore, develop and prototype reactive polymorphous computing concepts; (3) explore, develop and prototype multi-dimensional verification and validation techniques for dynamic reactive missions; (4) provide early experimental testbeds and prototype polymorphous computing systems; and (5) extend PCA to enable early commercial product development and transition to the DoD and intelligence communities. The result will be a significant breakthrough in DoD warfighter capability.

(U) Two promising PCA architectures, eXtended Tera-op Reliable Intelligently Adaptive Processing System (TRIPS) and eXtended MOrphable Networked microARCHitecture (MONARCH), will bridge the gap between the prototypes developed in the PCA program and provide transition-ready solutions that can be adopted by DoD and intelligence agencies. This effort includes performing product-level development of processor chips, multi-modules and software development environments planned for future deployment by DoD and intelligence end users.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

(U) This research effort will also extend the polymorphic research into developing a silicon compiler targeted at “maskless lithography.” Recent work in “maskless lithography” shows promise for avoiding the time and costs associated with the complex masks currently required for digital chip development. In addition, this technique would allow ‘system on a wafer’ development to support low volume systems while providing low cost production and quick turnaround.

(U) Additionally, as more and more chip fabrication is outsourced and the U.S. becomes more susceptible to faults and malicious hardware components, the need for autonomously adaptive mechanisms has become apparent as another extension of the PCA program. The self monitoring hardware in conjunction with co-developed software will incorporate cognitive techniques to determine the state and health of the processor, and based on the evaluation, will reconfigure, correct or shut down the processor to minimize the impact of a fault or malicious hardware. This self-aware trusted computing technology will enable the delivery of a more robust, self correcting trustable computing system.

(U) The resulting PCA technology will mark a new generation of on-board, embedded computing processing capabilities that will be mission and technology agnostic yet highly optimizable for each new mission scenario. This processing capability will provide tactical and strategic mission tempo opportunities as well as technical upgradeability over the life of the computing system. Based on an average of four major upgrades over a 30-year period, significant savings of up to 45 percent in development and deployment costs may be achieved over the life of a typical DoD embedded computing system.

(U) Program Plans:

- Fabricated and delivered the xMONARCH chip.
- Prototype and evaluate the TRIPS chip for implementing novel TRIPS Explicit Data Graph Execution architecture and the TRIPS compiler for implementing backend optimizations.
- Model, simulate and characterize complete candidate polymorphic computing systems including hardware elements, morphware, run-time systems and tools.
- Perform early small scale proof-of-concept testing, integration and evaluation of early polymorphic computing architecture prototypes.
- Demonstrate and quantify the potential of full up polymorphic computing architecture systems for the DoD and their complementary commercial viability.
- Select, develop, and perform a DoD risk reduction effort for a multi-mission application.
- Set the stage for technology transition to commercial and defense contractor communities in support of DoD applications.

UNCLASSIFIED

R-1 Line Item No. 19

Page 35 of 42

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- Perform early commercial product development and transition to the DoD and intelligence on-board embedded processing communities.
- Create a unique development environment chain - the silicon compiler - from high level application representation to implementation using a breakthrough high-speed, high-yield maskless lithography fabrication approach.
- Initiate a study to identify potential new hardware architectures and candidate approaches, such as master/slave methods where the "slave" collects and condenses data.
- Explore techniques to enable computing systems to self-monitor their state, identify unexpected or unwanted system behavior, and transparently adapt in real time.

	FY 2006	FY 2007	FY 2008	FY 2009
Vertically Interconnected Sensor Arrays (VISA)	3.995	5.200	3.000	2.500

(U) The Vertically Interconnected Sensor Arrays (VISA) program will develop and demonstrate vertically interconnected, focal plane array (FPA) read-out technology capable of more than 20-bits of dynamic range, enabling significant advances in the functionality of infrared systems. The extremely high dynamic range will be accomplished by novel multilayer read-out circuits. These circuits will enable imaging at more than 20-bits of dynamic range, whereas the current state of the art is over an order of magnitude lower. Adaptive read-out circuits will be vertically connected to individual detectors in either monochromatic or stacked multicolor 2D staring arrays. The ability to bring signals directly from the detectors to the read-outs (i.e., vertical interconnection) without first going through row-column multiplexers will allow for high frame rates concurrently with high resolution images. A companion application-oriented program is funded in PE 0603739E.

(U) Program Plans:

- Develop a wafer stacking process incorporating high-density vias and design novel circuits that enable high frame rates, counter-measure hardening and adaptive signal processing functions on a concept test chip.
- Demonstrate a high dynamic range Analog/Digital VISA technology based sensor designed with advanced high performance circuit architecture implemented in stacked semiconductor process with high-density interconnections.
- Determine the best bands for improving the detection of objects in varying degrees of fog.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
Lidar on a Chip	0.000	0.000	3.500	5.000

(U) The Lidar on a Chip program will develop a lidar system based on novel chip technologies/architectures resulting in significantly reduced (>> 10X) lidar system size, cost, and weight. Technology will be developed to allow both photonics and electronics to be fabricated on the same substrate, enabling the laser, signal processing, supporting subsystem components and the transmit and receive beam components to be implemented as chip-scale elements. This technology will enable the development of small-scale seeker systems. Reducing the size, weight and cost of a lidar system will revolutionize precision targeting systems.

(U) Program Plans:

- Develop and demonstrate fabrication technology.
- Demonstrate functional performance of array in laboratory scale devices.
- Develop and demonstrate brassboard array performance and scaling relationships.
- Design, develop, and test a prototype system.

	FY 2006	FY 2007	FY 2008	FY 2009
Structured ASIC Design (StASD)	0.000	0.000	3.500	5.500

(U) Currently Application Specific Integrated Circuits (ASIC) have a 20-30X performance advantage over general-purpose programmable processors, which is critical for high performance systems and platforms. The current ASIC design solutions are high in cost, require extensive time to design, apply to a single application, and need dedicated hardware, making them unattainable for most critical DoD systems. Also, when customizing ASICs for multiple applications, the overhead costs greatly increase in terms of performance density, clock speeds, and high power. The development of a Structured ASIC Design will provide the performance advantages of a customized ASIC but without the high overhead costs of programmable or fine-grain reprogrammable devices. The result will be highly novel, customizable ASICs that will dramatically enhance DoD applications in terms of cost, time to design, and performance.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Determine which common high performance functional elements provide the best option for high performance functionality at the appropriate level and capability of interconnects for the optimal customization.
  - Characterize, identify and implement interconnects to customize devices to the application.
  - Develop an ASIC implementation-based functionality layer to provide common, high-performance ASIC functional elements.

	FY 2006	FY 2007	FY 2008	FY 2009
Cognitively Augmented Design for Quantum Technology (CAD-QT)	1.120	2.000	0.000	0.000

(U) The Cognitively Augmented Design for Quantum Technology (CAD-QT) study phase program has developed learning-based optimization tools and represents a stepping stone towards an intelligent search engine capable of guiding the designer through the complex trade spaces of quantum device design.

- (U) Program Plans:
- Validate CAD-QT system by employing it to design optoelectronic modulator devices performing significantly beyond the current state of the art.
  - Investigate the exploitation of new fields of nanophotonics and plasmonics in which metal nanostructures convert electromagnetic radiation into charge density waves.

	FY 2006	FY 2007	FY 2008	FY 2009
Direct Analog To Target ID - Non-Linear Math for Mixed Signal Microsystems	7.401	6.302	3.089	0.000

(U) The principal goal of this program is to demonstrate a significant linearity enhancement capability based upon a digital signal processing approach, implemented in a high performance, very large scale integration (VLSI) chip that will enable wideband high-dynamic range sensor systems to be developed in a cost effective manner.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research	<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- (U) Program Plans:
- Develop broadly applicable methodologies for exploiting novel encoding strategies, closed loop adaptive equalization, integration of sensing and processing, and application-specific knowledge in order to provide revolutionary advances in information conversion.
  - Explore novel architectures leveraging intelligent pre-processing based upon space, time, and mathematical transformations of analog measurements and employing cooperative integration of analog and digital processing to obtain required system level performance.
  - Work with new classes of quantization devices based on novel “error correcting” representations of numbers, such as beta encoders, phase encoders, geometric invariants.

	FY 2006	FY 2007	FY 2008	FY 2009
Reliable Efficient Scalable Computing with Unreliable Elements (RESCUE)	0.000	0.000	4.000	5.000

(U) This program will develop hierarchical error correction and redundancy mechanisms right down to the gate level to compensate for device level errors and deliver reliable computing performance from Probabilistic-Complementary Metal Oxide Semiconductors (P-CMOS) devices scaling towards intrinsic statistical imperfection. These novel approaches will be adjustable to provide accuracy according to the requirements of particular applications, enabling optimization of power-performance trades at the level. Particular targets for applications will be high performance embedded signal and image processing tasks including radar image formation, video compression, and speech recognition. The RESCUE program will help sustain the advantages of Moore’s law scaling for a wide variety of DoD’s critical embedded signal processing and analysis applications. Significant benefits in energy reduction without loss of performance will be available almost immediately.

- (U) Program Plans:
- Devise P-CMOS computational building blocks and primitives such as Finite Impulse Response (FIR) filter, Fast Fourier Transformer (FFT), on up to Synthetic Aperture Radar (SAR) processing.
  - Develop systematic automation for support of non-uniform probabilistic design.
  - Characterize tradeoff between application quality and savings through novel metrics such as Energy-Performance Product (EPP).
  - Demonstrate defect-tolerant probabilistic adder design.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA2 Applied Research		<b>R-1 ITEM NOMENCLATURE</b> Electronics Technology PE 0602716E	

- Perform error correction through augmented probabilistic designs, including use of Chernoff tail bounds to contain redundancy. Use duality to extend temporal (noise) variations to spatial (parameter) variations (e.g., dual threshold voltages).

	FY 2006	FY 2007	FY 2008	FY 2009
National Secure Foundry Initiative	1.200	2.000	0.000	0.000

(U) The Secure Advanced Fabrication Facility for Electronics (SAFFE) aims to support and develop nanoelectronics innovations in support of homeland security and national defense applications, with target products ranging from power electronics systems, advanced superconductors, integrated “nanochip” solutions for lithography, 3-D integration, device modeling and simulation, and metrology applications. Scaling down of semiconductor device feature sizes has led to advanced electronic components and new capabilities for signal and data processing. This program pursued research concepts for shrinking semiconductor devices to the nanoscale and explored applications to integrated microsystems.

	FY 2006	FY 2007	FY 2008	FY 2009
Semiconductor Nanoelectronics Research	0.500	0.000	0.000	0.000

(U) Scaling down of semiconductor device feature sizes has led to advanced electronic components and new capabilities for signal and data processing. This program pursued research concepts for shrinking semiconductor devices to the nanoscale and explored applications to integrated microsystems.

	FY 2006	FY 2007	FY 2008	FY 2009
Characterization, Reliability & Applications for 3-D Microdevices	0.000	2.600	0.000	0.000

- (U) Develop innovative processing instrumentation for the fabrication of Three-Dimensional (3-D) Microdevices.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research		R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E	

	FY 2006	FY 2007	FY 2008	FY 2009
3D Technology for Advance Sensor Systems	0.000	2.200	0.000	0.000

(U) Explore 3D Technology innovation for application to Advance Sensor Systems.

(U) **Program Change Summary:** *(In Millions)*

	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	239.959	246.978	244.651	244.775
Current Budget	220.011	239.370	213.529	219.844
Total Adjustments	-19.948	-7.608	-31.122	-24.931
Congressional program reductions	-13.800	-14.408		
Congressional increases	0.000	6.800		
Reprogrammings	0.000			
SBIR/STTR transfer	-6.148			

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Electronics Technology PE 0602716E, R-1	

**(U) Change Summary Explanation:**

FY 2006	The decrease reflects the SBIR/STTR transfer and the Section 8040 rescission.
FY 2007	The decrease reflects congressional cuts to the following programs: Clockless Logic, Metaphoric Computing, Advanced Digital Receiver Technology, TEAM, Terahertz Imaging Focal-Plane Technology, AFPA, Bio-Electronics and Photonics, Linear Photonic RF Front End Technology, Multiple Optical Non-Redundant Aperture Generalized, and a reduction for Section 8106 Economic Assumptions. The decreases are offset by congressional adds to: SAEF, 3-D Technology for Advanced Sensor Systems, and Innovative Processing Instrumentation for Fabrication of 3-D Microdevices.
FY 2008/2009	Decrease reflects overall funding reductions resulting from rephasing of outyear milestones.

**(U) Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

R-1 Line Item No. 19

Page 42 of 42

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Advanced Aerospace Systems PE 0603286E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	50.272	80.474	86.385	95.703	98.923	100.923	128.923	142.021
Advanced Aerospace Systems AIR-01	50.272	80.474	86.385	95.703	98.923	100.923	128.923	142.021

**(U) Mission Description:**

(U) The Advanced Aerospace Systems program element is budgeted in the Advanced Technology Budget Activity because it addresses high payoff 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.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Heliplane (formerly Advanced Aeronautics Demonstration)	10.600	14.800	17.400	13.000

(U) The Heliplane program will design, develop and flight test an air vehicle that combines the vertical take-off and landing (VTOL) and low disk loading characteristics of a helicopter with the speed and efficiency characteristics of a fixed wing aircraft. The Heliplane demonstrator aircraft will be tailored to a Combat Search and Rescue (CSAR) mission with a 400 mph cruise speed, a 1,000 lb payload, and an unrefueled range of 1,000 miles. The Heliplane program will conduct a combination of analysis and experiments to develop and demonstrate key enabling technologies. Once key enabling technologies have been demonstrated, a preliminary and detailed design of the Heliplane system will be completed, a full scale test of the rotor system will be conducted, and a Heliplane demonstrator will be fabricated and flight tested. Potential customers include the Army, Special Operations Command (SOCOM), Marines, and AFSOC.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Aerospace Systems PE 0603286E	

- (U) Program Plans:
- Perform Heliplane system trade studies and develop conceptual design.
  - Develop and conduct risk-reduction demonstrations of key Heliplane technologies and components.
  - Demonstrate capability for stable operation of the full-scale Heliplane rotor system at high speed in a wind tunnel.
  - Complete preliminary and detailed design of Heliplane demonstrator.
  - Fabricate Heliplane demonstrator aircraft.
  - Conduct flight tests to validate Heliplane performance.

	FY 2006	FY 2007	FY 2008	FY 2009
Oblique Flying Wing (OFW)	7.028	16.500	27.150	40.850

(U) The Oblique Wing aircraft is a flying wing, which flies with variable sweep to improve high speed characteristics. The variable sweep is achieved asymmetrically on the oblique wing, with one wing swept forward and the other swept aft. A supersonic, variable sweep oblique flying wing would be efficient in both high speed cruise and low speed loiter, would be compatible with survivability requirements, and would have a structurally efficient airframe. Possible missions that would take advantage of the combination of high and low speed performance could include: penetrating intelligence, surveillance, reconnaissance, long range strike, hunter/killer, and multimission aircraft. A supersonic aircraft capable of extremely long loiter times would have a revolutionary impact on the battlefield, necessitating fewer combat aircraft and fewer tankers to accomplish mission objectives. The goal of the Oblique Flying Wing (OFW) program is to expand the design space for future aircraft concepts, particularly for those missions that demand both supersonic speed and long endurance. The potential for a unique combination of excellent high speed and low speed performance would enable rapid deployment and long loiter time, for example, in surveillance or combat air patrol (CAP) roles. The OFW program will integrate technologies such as advanced controls to develop and fly a small-scale technology demonstrator vehicle. The program will also identify key design requirements for the objective system, allowing the services to evaluate the technology for implementation in future operational systems. The anticipated transition partner is the Air Force.

- (U) Program Plans:
- Develop oblique wing concept design.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Aerospace Systems PE 0603286E	

- Define, develop, and demonstrate key oblique wing component technologies.
- Begin system design for an objective oblique wing system and a flight demonstrator.
- Develop preliminary design and detailed design of oblique wing flight demonstrator aircraft.

	FY 2006	FY 2007	FY 2008	FY 2009
Heavy Fuel Engine	6.612	6.729	5.535	3.153

(U) The Heavy Fuel Engine program will develop and demonstrate a heavy-fuel, lightweight, and efficient engine for air vehicles. In the future, heavy fuel (diesel or JP-8) may be the only logistic fuel for the battlefield. Conventional heavy fuel engines are too heavy for air vehicles and, at the desired size, not efficient enough. Innovative and advanced diesel engine designs are being developed to achieve both efficiency and a significant reduction in weight. Such engines will enable air vehicles increased maximum range and endurance while operating on diesel fuel. Novel approaches to achieving challenging performance goals include an opposed piston, opposed cylinder (OPOC) concept and a very low friction in-line opposed piston configuration. The OPOC engine is designed to achieve sustained high power at high altitude and to minimize the impact of lapse rate. The Low Friction Engine (LFE) is designed to operate without conventional piston rings which are a principal cause of internal combustion engine friction and diminish the amount of useful work that is available from an engine. Detailed design, fabrication, and testing is being conducted to assess engine performance and reliability. Initial engine technology transition planning identified the A160 air vehicle as a promising platform for a heavy fuel engine. Integration of a heavy fuel engine could potentially double endurance for a given weight of fuel. Potential customers include the Army, Special Operations Command (SOCOM), and Marines.

(U) Program Plans:

- Completed single OPOC prototype engine performance and endurance testing.
- Complete final OPOC design and assembly.
- Conduct full OPOC twin-module engine tests.
- Demonstrate performance and reliability of optimized engines at 38% efficiency, a power to weight ratio of 0.9hp/lb, and producing 450 hp at 15,000 ft.
- Conduct LFE comparative demonstration of ringless piston operation for low friction and viable operation.

**UNCLASSIFIED**

R-1 Line Item No. 32

Page 3 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Aerospace Systems PE 0603286E	

- Complete Low Friction Engine (LFE) performance, structural and thermodynamic analysis, assessment, and conceptual design.
- Demonstrate a single cylinder engine for incremental performance capability.
- Demonstrate four-cylinder engine for full performance.
- Integrate prototype engines with the A160 air vehicle.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Aerospace System Concepts	3.254	4.345	3.500	2.500

(U) Studies conducted under this program examine and evaluate emerging aerospace technologies and system concepts for applicability to military use. This includes the degree and scope of potential impact/improvements to military operations, mission utility, and warfighter capability. Studies are also conducted to analyze emerging aerospace threats along with possible methods and technologies to counter them. The feasibility of achieving potential improvements, in terms of resources, schedule, and technological risk, is also evaluated. The results from these studies are used, in part, to formulate future programs or refocus ongoing work. Topics of consideration include: methods of defeating enemy anti-aircraft attacks; methods to intercept and defeat enemy unmanned air vehicles (UAVs); autonomous refueling for air vehicles; munition technologies to increase precision, range, endurance, and lethality of weapons for a variety of mission sets; novel launch systems; and air vehicle control, power, propulsion, materials, and architectures.

- (U) Program Plans:
- Perform studies of candidate technologies and develop system concepts.
  - Conduct modeling and simulation of system architectures and scenarios.
  - Conduct enabling technology and sub-system feasibility experiments.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development		R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E	

	FY 2006	FY 2007	FY 2008	FY 2009
A160	7.000	7.000	5.000	0.000

(U) The A160 program will exploit a hingeless, rigid rotor concept operating at the optimum rotational speed to produce a vertical take-off and landing (VTOL) unmanned air vehicle (UAV) with low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2,000 nm) and/or endurance (>20 hours). The focus of the remaining program is on the final development and demonstration of the A160 turbo-shaft variant. Proof of concept flight test will demonstrate platform performance goals, most notably, endurance, a 15,000 feet high altitude hover-out-of-ground effect capability, payload carrying and speed. This program will also demonstrate airworthiness, reliability, and autonomous capabilities of the vehicle. The A160 concept has the potential to meet a range of surveillance and targeting, communications and data relay, crew recovery, resupply of forces in the field, and special operations missions in support of Army, Navy, Marine Corps, and other agency needs. The program also provides a platform for integration and testing of highly efficient heavy fuel engine technologies. These technologies can further advance current range and endurance. The A160 program will transition after completion of this Phase.

(U) Program Plans:

- Complete development of the turbo-shaft A160 including the major components of engine, flight control system and transmission system.
- Demonstrate performance goals through flight tests.

	FY 2006	FY 2007	FY 2008	FY 2009
Cormorant Unmanned Air Vehicle (UAV)	9.600	5.100	0.000	0.000

(U) The Cormorant Unmanned Air Vehicle (UAV) program examined the feasibility of a UAV that may be deployed from the sea without carrier support. The program explored concepts that launch from both the sea surface and submarines. Technical challenges included underwater recovery and docking of the aircraft with a submerged submarine, aircraft structural integrity and water tightness at submarine launch depths and

**UNCLASSIFIED**

R-1 Line Item No. 32

Page 5 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Aerospace Systems PE 0603286E	

on the surface, aircraft dynamics at the air/sea interface, engine technology to survive periodic immersion in salt water, and advanced composite materials development to withstand sea-surface operations.

- (U) Program Plans:
- Conducted feasibility studies; conducted modeling and simulation of vehicle behaviors in the air/sea interface.
  - Performed concept design studies.
  - Performed engine quick start demonstration and engine concept development.
  - Conducted initial technology demonstrations for underwater in-haul and docking of an air vehicle in a series of full scale tests.

	FY 2006	FY 2007	FY 2008	FY 2009
Critical Munition Capability	6.178	6.000	0.000	0.000

(U) The Critical Munition Capability program consisted of four efforts: Hypersonic Joint Attack Munition (HyperJAM), Multi-target Autonomous Loitering Littoral Munition (MAULLM), Battlefield Electronically Disruptive Loitering Attack Missile (BEDLAM), and Deep Interdiction with Multiple Engagements (DIME). The goal of each of these efforts was to provide the warfighter with a range of weapons that enable effective, precise, responsive, and decisive disruption to enemy forces.

(U) HyperJAM explored the ability to deliver GPS precision guided weapons to high value, well defended, and relocatable targets with range capability in excess of 400 nm. HyperJAM investigated the use of conventional rocket technology (black brandt rocket) integrated with a modified aerodynamically enhanced Joint Direct Attack Munition (JDAM) high speed nosecone to deliver MK84 munitions to precise locations. MAULLM developed concepts and technologies for a containerized, platform-independent multi-mission weapon concept that could provide rapid response and lethality in packages with significantly lower missile unit cost, decreased logistical support and lower life-cycle costs, while increasing flexibility compared to current Naval gun and missile systems. BEDLAM developed concepts and technologies for detection, exploitation, and disruption of a wide variety of enemy electronic emissions which could be integrated into a mission module suitable for use on small loitering missiles to establish patterns or meetings with other emitters to aid in intelligence and targeting. DIME investigated the trade-space

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E	

between missiles and aircraft, with the objective of improving the operational utility of aircraft and UAVs with the support requirements, acquisition characteristics, and attritability of munitions.

(U) Program Plans:

- Completed HyperJAM simulation studies to determine range capability and control requirements for potential Army, Navy, and Air Force customers.
- Developed system level requirements and CONOPS for air and gun delivered munitions.
- Conducted preliminary concept studies for MAULLM and BEDLAM.
- Developed DIME mission concepts and technical requirements studies.

	FY 2006	FY 2007	FY 2008	FY 2009
Dual Mode Small Gunship	0.000	6.000	7.600	8.400

(U) The objective of the Dual Mode Small Gunship program is to build, test and fly a low-cost small aircraft, configured with sensors, weapons and special equipment that are controlled either remotely or by a crew onboard. The vehicle will demonstrate persistent, sustained gunship and strike mission capabilities with troops on the ground directly commanding the aircraft’s weapons and sensors. The gunship will give the ground warfighter particular advantage in urban environments where it will operate with high availability, fast response, precision strike and low collateral damage. The ability to have a pilot on-board will allow for easy deployment to theater and safe operation over populated areas by allowing the pilot to interface with the air traffic control infrastructure rather than the current, cumbersome method of deploying large UAVs. The plan to “unman” an existing aircraft also minimizes development costs. The Dual Mode Small Gunship is expected to have low development and procurement costs, high endurance and range, a large payload, and high dash speeds with a day/night adverse weather capability. Potential customers include the Army, SOCOM, Marines, and AFSOC.

(U) Program Plans:

- Complete a preliminary feasibility study for modification of an existing low cost aircraft.
- Modify an existing low cost aircraft for use as an “optionally piloted” aircraft, with weapons systems and sensors.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Aerospace Systems PE 0603286E	

- Demonstrate ability to control the aircraft, its weapons and sensors from the ground.

	FY 2006	FY 2007	FY 2008	FY 2009
Close Air Support Technology for Loitering Engagement (CASTLE)	0.000	2.500	5.000	7.100

(U) The Close Air Support Technology for Loitering Engagement (CASTLE) program will develop alternatives to current, manned systems and explore approaches to provide persistent on-demand overhead fire support with gun-ship like precision, tailored lethal effectiveness and unit directed responsive command and control. Key technologies to be analyzed, developed and integrated under CASTLE include 1) affordable, survivable, and persistent unmanned aircraft, 2) weapons consistent with man-in-the loop close air support application, such as auto-loading Electro Magnetic (EM) guns, directed energy weapons, vertical launch missiles, or deep magazine traditional guns and precision bombs, 3) sensors for targeting and designation, and 4) an adaptive command and control system to permit small unit request, coordination, and direction of supporting fires. Potential customers include the Army, SOCOM, Marines, and AFSOC.

(U) Program Plans:

- Evaluate candidate technologies for CASTLE.
- Conduct initial concept trade-off for preliminary CASTLE system designs.
- Perform modeling and simulation of alternative candidate air system architectures to assess effectiveness of alternative CASTLE approaches.
- Complete preliminary design of air vehicle design concept and development.
- Perform CASTLE technology risk reduction experiments and demonstrations.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development		R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E	

	FY 2006	FY 2007	FY 2008	FY 2009
Aircraft Self Protection (ASP)	0.000	6.000	7.000	9.000

(U) The Aircraft Self Protection (ASP) program will explore the active protection of slow moving, high altitude aircraft systems with guided missiles or high energy laser weapons as an alternative/complement to passive defense by signature control. Today such aircraft rely on stealth technology to avoid detection and engagement by long range surface to air missile threats. In the future, the unique advantage enjoyed by the United States may be eroded by technological advances, and stealthy aircraft often give up their advantage in detectibility when they utilize active radar and laser sensors in the conduct of their mission. An active aircraft self-defense system could relax the design constraints imposed by signature control, allowing a greater range of platform capabilities. Because lasers provide “speed-of-light” response and a deep magazine, we will examine their suitability relative to the more conventional missile based solutions. The ASP program will evaluate both pod-mounted and fully integrated system concepts and will develop and demonstrate missile detection, threat tracking, engagement, and defeat at a safe range. Potential customers include the Army, SOCOM, Marines, and AFSOC.

(U) Program Plans:

- Perform ASP system trade-off analysis, resulting in system size, weight, power and effectiveness criteria.
- Evaluate alternative high energy laser designs and missile or projectile technologies for ASP applications.
- Demonstrate integration of missile warning and tracking capabilities with lightweight beam director technology against incoming missile threats.
- Select initial ASP design concept and perform development to preliminary design review.

**UNCLASSIFIED**

R-1 Line Item No. 32

Page 9 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Aerospace Systems PE 0603286E	

	FY 2006	FY 2007	FY 2008	FY 2009
Rapid Eye	0.000	0.000	4.500	7.500

(U) The goal of the Rapid Eye program is to develop a high altitude, long endurance unmanned aircraft that can be rocket-deployed from the continental United States world-wide within 1-2 hours to perform intelligence, surveillance, reconnaissance (ISR), and communication missions. The enabling technologies are inflatable/folding structures, stable and dense energy storage, and low-oxygen propulsion. Rapid Eye will provide decision makers rapid-reaction ISR and persistent communication capability for emerging situations.

(U) Program Plans:

- Develop Rapid Eye preliminary design, risk management plan, and technology and system maturation plan.
- Begin conceptual design study of system trades, effectiveness, and affordability through modeling and simulation.
- Develop sufficient system concept fidelity to validate program goals and objectives.
- Perform multi-team study of aerodynamic decelerators, inflatable wings, and propulsion concepts.

	FY 2006	FY 2007	FY 2008	FY 2009
VULTURE	0.000	0.000	3.700	4.200

(U) The goal of the Very-high altitude, Ultra-endurance, Loitering Theater Unmanned Reconnaissance Element (VULTURE) program is to develop a high altitude, long endurance (multi-month) unmanned aircraft to perform intelligence, surveillance, reconnaissance (ISR), and communication missions over an area of interest. The enabling technologies are solar collection, dense and efficient energy storage, and improved reliability for components, and lightweight structures. VULTURE, in effect, will be a retaskable, persistent satellite capability, in an aircraft package.

(U) Program Plans:

- Perform multi-team conceptual design study of system trades, effectiveness, and affordability through modeling and simulation.

**UNCLASSIFIED**

R-1 Line Item No. 32

Page 10 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Aerospace Systems PE 0603286E	

- Develop sufficient system concept fidelity to validate program goals and objectives.
- Begin technology development in the areas of solar collection and energy storage.
- Begin sub-scale demonstration of components.

	FY 2006	FY 2007	FY 2008	FY 2009
Heavy Lift	0.000	4.500	0.000	0.000

(U) The Heavy Lift program explored technologies that would lead to novel STOL/VTOL air vehicle concepts and designs. The objective VTOL aircraft would have been optionally-manned and able to lift a 20-ton payload and carry it forward at speeds of 200+ knots with a tactical radius of 400 miles. The program examined technology advances in advanced rotors, propellers, hybrid-mode engines, controls, and advanced composite airframes.

- (U) Program Plans:
- Performed trade studies.

	FY 2006	FY 2007	FY 2008	FY 2009
Heavy Fuel Engine Development	0.000	1.000	0.000	0.000

(U) The Heavy Fuel Engine program will develop and demonstrate a heavy-fuel (e.g. diesel), lightweight, and efficient engine for air vehicles. Innovative and advanced diesel engine designs are being developed to achieve both efficiency and a significant reduction in overall weight. Such engines will enable air vehicles increased maximum range and endurance while operating on a logistic fuel.

- (U) Program Plans:
- Assess initial concepts.
  - Complete preliminary design.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603286E	

(U)	<b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
	Previous President's Budget	54.594	115.829	202.587	250.823
	Current Budget	50.272	80.474	86.385	95.703
	Total Adjustments	-4.322	-35.355	-116.202	-155.120
	Congressional program reductions	-3.000	-36.355		
	Congressional increases	0.000	1.000		
	Reprogrammings	0.000			
	SBIR/STTR transfer	-1.322			

(U) **Change Summary Explanation:**

FY 2006                      The decrease reflects SBIR/STTR transfer and the Section 8040 rescission.

FY 2007                      The decrease reflects congressional cuts to Heavy Fuel Engine, Cormorant, Global Range Transatmospheric Vehicle, A160, Advanced Aeronautics Demonstration, Critical Munition Technology, Seaplane UAV, Heavy Lift, CASTLE, and a reduction for Section 8106 Economic Assumptions. The decreases are offset by a congressional add for Heavy Fuel Engine Development.

FY 2008/09                      The decreases reflect overall funding reductions due to the cancellation of several major programs such as the Cormorant.

(U) **Other Program Funding Summary Cost:**

A160	FY 2006	FY 2007	FY 2008	FY 2009
Army S&T, Phase I	10.000	15.000	0.000	0.000
Army S&T, Phase II	9.190	18.740	0.000	0.000

**UNCLASSIFIED**

R-1 Line Item No. 32

Page 12 of 12

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	210.736	253.950	224.551	225.238	246.443	244.598	249.467	258.867
Space Programs and Technology SPC-01	210.736	253.950	224.551	225.238	246.443	244.598	249.467	258.867

**(U) Mission Description:**

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

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

(U) Systems development is also required to increase the interactivity of space systems, space-derived information and services with terrestrial users. Studies under this project include technologies and systems that will enable satellites and microsatellites to operate more effectively by increasing maneuverability, survivability, and situational awareness; enabling concepts include solar thermal propulsion, novel ion-thruster applications, payload isolation and pointing systems.

**UNCLASSIFIED**

R-1 Line Item No. 33

Page 1 of 22

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Orbital Express Space Operations Architecture	35.271	34.711	0.000	0.000

(U) The goal of the Orbital Express Space Operations Architecture program is to validate the technical feasibility of robotic, autonomous on-orbit refueling and reconfiguration of satellites to support a broad range of future U.S. national security and commercial space programs. Refueling satellites will enable frequent maneuver to improve coverage, change arrival times to counter denial and deception and improve survivability, as well as extend satellite lifetime. Electronics upgrades on-orbit can provide regular performance improvements and dramatically reduce the time to deploy new technology on-orbit. The Orbital Express advanced technology demonstration will design, develop and test on-orbit a prototype servicing satellite (ASTRO) and a surrogate next generation serviceable satellite (NextSat). The elements of the Orbital Express demonstration, coordinated with Air Force Space Command and Air Force Space and Missile Command, will be tied together by non-proprietary satellite servicing interfaces (mechanical, electrical, etc.) that will facilitate the development of an industry wide on-orbit servicing infrastructure. NASA will apply the sensors and software developed for autonomous rendezvous and proximity operations to reduce risk for collaborative human-robotic operations in space for the NASA Exploration Initiative. Launch of the demonstration system is scheduled for early 2007 on the Air Force Space Test Program's STP-1 mission.

**(U) Program Plans:**

- Develop and validate software for autonomous mission planning, rendezvous, proximity operations and docking.
- Design, fabricate, and test on-orbit robotic satellite servicing, including fuel and electronics transfer, deployment of and operations with a micro-satellite.
- Perform utility assessments of on-orbit servicing in conjunction with operational customers and plan for technology transition.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
Space Surveillance Telescope	18.592	19.771	12.833	3.000

(U) The Space Surveillance Telescope (SST) program will develop and demonstrate an advanced ground-based optical system to enable detection and tracking of faint objects in space, while providing rapid, wide-area search capability. A major goal of the SST program is to develop the technology for large curved focal plane array sensors to enable an innovative telescope design that combines high detection sensitivity, short focal length, wide field of view, and rapid step-and-settle to provide orders of magnitude improvements in space surveillance. This capability will enable ground-based detection of un-cued objects in deep space for purposes such as asteroid detection and space defense missions. The Air Force will participate in the DARPA funded developmental testing of SST and then take over operation of SST as a sensor in the Air Force Space Surveillance Network. An MOA has been established with Air Force Space Command for transition at the conclusion of Phase II that is anticipated to be completed in FY 2009.

(U) Program Plans:

- Develop, fabricate, and integrate a mosaic of curved focal plane arrays into a wide field-of-view detector system.
- Develop, fabricate, and integrate a 3.5m aperture telescope with both a wide field of view and high sensitivity.
- Develop, test, and validate software for autonomous telescope operations and data reporting.
- Design and fabricate telescope enclosure and supporting infrastructure at White Sands Missile Range.
- Validate end-to-end telescope performance and surveillance operations.
- Perform operational evaluation in conjunction with the Air Force.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
Innovative Space-Based Radar Antenna Technology (ISAT)	43.000	22.000	0.000	0.000

(U) The Innovative Space-Based Radar Antenna Technology (ISAT) effort designed radically new enabling technologies and design methods for extremely large space-based radio frequency (RF) antenna technologies necessary for tactical-grade ground moving target indicator (GMTI) radar. Up to 300 meters long electronically scanned antenna (ESA) designs were developed by leveraging major advances in novel materials (such as rigidized inflatables and shape memory polymers), packing techniques and ultra lightweight low-power density RF electronics. An antenna of this size would enable a medium earth orbit (MEO) constellation that would provide 24/7 true continuous coverage with 10 to 12 satellites (about 96 satellites at low earth orbit (LEO) would be required to provide the same level of coverage). ISAT would also enable detection and tracking of all airborne targets. The ISAT program addressed the risk associated with two major technical obstacles: 1) the reliable and controllable deployment of a ~300 meter long ESA with a linear compaction ratio of 100:1; and 2) the on-orbit calibration (particularly on transmit) and control of the ISAT antenna. Novel power distribution systems were also investigated. The program conducted ground-based risk reduction experiments demonstrating the accuracy of the constitutive models for deployment and control of large antenna structures and also developed concepts of operations, performance predictions and lifecycle cost models for the selected designs, as well as investigated the applicability of the technologies to other missions. The program ended in FY 2007.

(U) Program Plans:

- Tested the mechanical and environmental properties of materials and structural components.
- Simulated metrology and calibration approaches for large space antenna structures.
- Initiated development of next-generation lightweight electronics, materials and deployment structures.
- Designed risk reduction demo experiments.
- Performed ground-based risk reduction experiments of the metrology and calibration approaches in preparation for on-orbit demonstration.
- Perform ground-based risk reduction experiments for packaging and deployment mechanisms and materials, including simulation of mechanical and thermal loads.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
Novel Satellite Communications	8.500	16.275	15.622	9.639

(U) The aim of the Novel Satellite Communications (NSC) program is the development of a multi-user satellite communications (SATCOM) system that allows ground-based users with handheld radios to communicate with the satellite at high data rates, even when the users are close to multiple jammers and/or located in urban (i.e. severe multi-path) settings. This will be accomplished through novel signal processing, communications and coding techniques. The NSC technology will transition to the U.S. Navy (SPAWAR) and U.S. Air Force (SMC) following the NSC demonstration in 2009.

- (U) Program plans:
- Determined feasibility of novel concepts to enable robust communications in the presence of multiple nearby jammers.
  - Develop signal processing, communications and coding techniques that fully exploit the novel concepts to provide a robust anti-jam capability in the presence of multiple nearby jammers.
  - Carry out proof-of-concept demonstrations.

	FY 2006	FY 2007	FY 2008	FY 2009
Integrated Sensor is Structure (ISIS)	0.000	23.318	26.200	35.000

(U) The ISIS program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship that will address the nation's need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly-integrated lightweight multi-purpose airship structure - completely erasing the distinction between payload and platform. The ISIS concept includes 99% on-station 24/7/365 availability for Simultaneous Airborne Moving Target Indicator (AMTI) (600 kilometers) and Ground-Based Moving Target Indicator (GMTI) (300 kilometers) operation; 12-plus months of autonomous, unmanned flight; hundreds of wideband in-theater covert communications links; responsive reconstitution of failed space assets; plus

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

CONUS-based sensor analysis and operation. The ISIS technology is planned for transition to the Army's PEO ASMD, Air Force Joint Warfighter Space and the Missile Defense Agency at the conclusion of Phase IV, which is anticipated to be completed by FY 2011. This program was funded under PE 0603767E, Project SEN-01 in FY 2006 and prior years.

(U) Program Plans:

- Developed objective system concept designs enabling simultaneous AMTI and GMTI operation, one year logistics-free operation, 99% on-station availability, and high-bandwidth covert communications.
- Identified specific mass-reducing technologies for key radar, power, and airship components.
- Develop and demonstrate lightweight technologies for system integration (i.e. high-energy density batteries, electronic circuits on thin-film barrier materials, advanced multi-purpose airship hulls, and regenerative fuel technologies).
- Design and simulate new radar modes: tracking air and ground targets through the clutter notch; detection and response to rockets, artillery, and mortars (RAM); detection of dismounted enemy combatants; and "track-all-the-way" fire-control.
- Design, build and demonstrate a fully-operational scaled flight system demonstrating complete system integration over an extended period (~3 months).

	FY 2006	FY 2007	FY 2008	FY 2009
Deep View	10.920	10.250	8.450	4.250

(U) The Deep View program will develop a high-resolution radar imaging capability to characterize objects in earth orbit. A special emphasis will be placed on imaging small objects at orbits ranging from low earth orbit (LEO) to geo-stationary orbit (GEO). The system will be based upon a large aperture imaging radar system redesigned to operate at very high power over very broad bandwidth at W-band. Key technology development will focus on: (1) transmitters capable of providing the required power to image at deep-space ranges over full bandwidth; and (2) an antenna design that maintains the necessary form factor over a very large aperture. The capabilities emerging from this program will enable the classification of unknown objects, such as space debris, as well as the monitoring of the health and status of operational satellites. DARPA established an MOA with the Air Force for this program in August 2004. The Deep View technology is planned for transition to the Air Force at the conclusion of Phase III, which is anticipated to be completed by FY 2010.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

- (U) Program Plans:
- Develop W-band gyro-twystron transmitter tubes.
  - Develop the technology for W-band power combining and frequency multiplexing, to obtain the required transmitter power over the required bandwidth for deep space imaging.
  - Complete transmitter and radar system design, retaining the current Haystack X-band capability.
  - Develop advanced signal processing software required by the new broadband high power transmitter approach.
  - Integrate into a low-power radar configuration providing LEO-only imaging capability.
  - Demonstrate LEO-GEO imaging capability using a full set of gyro-twystrons.

	FY 2006	FY 2007	FY 2008	FY 2009
Long View (formerly Ground Based Imaging)	0.000	7.496	13.809	19.789

(U) The Long View program will develop an inverse synthetic aperture laser radar (LADAR) that will enable the high-resolution imaging of geostationary satellites when coupled to a large aperture telescope. Specifically, the technologies being developed in the Long View program are an optical reference oscillator that is stable over the propagation time to a geostationary satellite (GEOSTAT) and back (about a quarter of a second) and autofocus algorithms that restore image quality that has been degraded due to atmospheric turbulence and optical reference oscillator instability over the imaging time (about 100 seconds). These two technologies are required in order to make inverse synthetic aperture LADAR systems feasible for objects in geostationary orbits.

- (U) Program Plans:
- Develop stable optical reference oscillator.
  - Develop and test autofocus algorithms.
  - Measure atmospheric turbulence statistics at sub-Hz frequencies.
  - Design, build, and test demonstration hardware.
  - Integrate hardware with telescope.
  - High resolution imaging of geostationary satellites.

**UNCLASSIFIED**

R-1 Line Item No. 33

Page 7 of 22

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
Falcon	38.600	51.500	50.000	49.500

(U) The Falcon program objectives are to develop and demonstrate hypersonic technologies that will enable prompt global reach missions. This capability is envisioned to entail a reusable Hypersonic Cruise Vehicle (HCV) capable of delivering 12,000 pounds of payload at a distance of 9,000 nautical miles from CONUS in less than two hours. The technologies required by a HCV include high lift-to-drag technologies, high temperature materials, thermal protection systems, and guidance, navigation, and control. Leveraging technology developed under the Hypersonic Flight (HyFly) program, Falcon will address the implications of hypersonic flight and reusability using a series of hypersonic technology vehicles (HTVs) to incrementally demonstrate these required technologies in flight. In order to implement this flight test program in an affordable manner, Falcon will develop a low cost, responsive Small Launch Vehicle (SLV) that can be launched for \$5M or less. In addition to HTV sub-orbital launches, the SLV will be capable of launching small satellites into low earth and sun-synchronous orbits and will provide the nation a new, small payload access to space capability. Thus, the Falcon program addresses many high priority mission areas and applications such as global presence and space lift. DARPA established an MOA with the Air Force for this program in May 2003 and with NASA in October 2004. Falcon capabilities are planned for transition to the Air Force.

(U) Program Plans:

- Conducted SLV first stage static firing and launch from Omelek Island.
- Conducted full scale size, subscale weight, air launch drop test.
- Conducted SLV responsive operations demonstration.
- Conducted HTV-2 preliminary design review.
- Conducted HTV-3X feasibility study.
- Conducted multiple full scale size, full scale weight air launch drop tests.
- Conducted SLV full scale engine firings.
- Conduct SLV risk reduction flight for TacSat-1 launch mission.
- Conduct critical design review of HTV-2 demonstration system, and initiate fabrication.
- Complete HTV-2 aeroshell prototype fabrication and conduct leading-edge arc-jet test.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

- Conduct critical design review of SLV, and initiate fabrication.
- Initiate concept design of the HTV-3X technology flight demonstration vehicle.
- Conduct SLV flight demonstration.
- Conduct flight testing of HTV-2 incorporating next generation hypersonic technologies.
- Conduct flight-testing of advanced reusable technologies for HCV.

	FY 2006	FY 2007	FY 2008	FY 2009
Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST)	2.000	0.000	0.000	0.000

(U) The Rapid On-Orbit Anomaly Surveillance and Tracking (ROAST) program developed technologies to enable low-cost, responsive spacecraft and capabilities, such as space situational awareness and blue force tracking. Key payload technologies included light-weight optics, adaptive focal plane array sensors, and efficient space-qualified receivers and processors.

- (U) Program Plans:
- Evaluated light-weight, large area optics fabrication capabilities.

	FY 2006	FY 2007	FY 2008	FY 2009
Sleight of HAND (SOH)	4.482	11.870	12.710	7.160

(U) This program will leverage technologies developed under the Air Force's High Frequency Active Auroral Research Program (HAARP) program. The effects of High Altitude Nuclear Detonations (HAND) are catastrophic to satellites. HAND-generated charged particles are trapped for very long periods of time, oscillating between the earth's north and south magnetic poles. This enhanced radiation environment would immediately degrade low earth orbiting (LEO) spacecraft capability and result in their destruction in a short period of time. The Sleight of HAND (SOH) program is a proof of concept demonstration of the technology and techniques to mitigate the HAND-enhanced trapped radiation. The goal of SOH is to accelerate the rate of decay of trapped radiation from the LEO environment by a factor of 10 over the natural rate of decay. In Phase

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

1, SOH will use a high power ground-based source of very low frequency (VLF) radiation propagating through the ionosphere to deflect the trapped radiation deep into the atmosphere. If the ground-based proof of concept shows VLF radiation remediation concepts are valid and cost-effective, a space-based demonstration that may lead to an operational capability will be pursued. If successful, follow-on programs to perform HAND produced radiation remediation will be pursued by the Air Force.

(U) Program Plans:

- Developed VLF propagation and radiation interaction/effects model.
- Constructed and deployed an instrumented buoy to sense and report VLF signal strength and effects of VLF on trapped radiation.
- Utilized the HAARP facility to perform 1-hop experiments to anchor VLF propagation and interactions model.
- Performed 2-hop experiments to further enhance the fidelity of VLF prediction codes.
- Use results of ground-based SOH experiments to develop requirements for a space-based SOH demonstrator.
- Evaluate requirements for space-based SOH demonstration.

	FY 2006	FY 2007	FY 2008	FY 2009
Suborbital Space Launch Operations / Improving Suborbital Operations	5.600	0.000	0.000	0.000

(U) The Suborbital Space Launch Operations/Improving Suborbital Operations program designed and developed an unmanned, reusable suborbital launch vehicle whose near term goal was to perform short duration testing of space flight hardware and ultimately to provide a platform for tactical battlefield surveillance.

(U) Program Plans:

- Developed a preliminary system design for the launch vehicle.
- Conducted system requirements review and initiate detailed design.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
Micro Electric Space Propulsion	3.236	4.689	6.748	0.000

(U) The Micro Electric Space Propulsion program (MEP) will demonstrate flexible, light-weight, high-efficiency, scalable micro-propulsion systems to enable a new generation of fast, long-lived, highly flexible, and highly maneuverable 1-100 kg-class satellites/spacecraft. In particular, the goals of the program are to demonstrate a thruster system capable of: (1) varying its specific impulse in real time across a range from 500 seconds to 10,000 seconds utilizing a single propellant, (2) operating with electrical thrust efficiencies in excess of 90% over significant portions of this range, (3) demonstrating a thruster specific mass less than 0.3 g/watt, and (4) demonstrating a propulsion system capable of delivering total mission delta-Vs for a 100 kg satellite in excess of 10 km/s. The MEP technology is planned for transition to the Air Force at the conclusion of Phase I, which is anticipated to be completed in FY 2008.

(U) Program Plans:

- Demonstrate proof-of-principle 1 watt thruster system capable of operating 50% efficiency at 2500 seconds and 7000 seconds specific impulse.
- Design 2-D thruster array.
- Develop and demonstrate required Microelectromechanical Systems (MEMS) fabrication process, including development of high-aspect ratio machining and conformal surface modification techniques.
- Develop robust system design capable of tolerating single emitter failure.
- Initiate propellant selection and optimization.
- Demonstrate thruster / propellant material compatibility.
- Demonstrate thruster operation.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
RAD Hard by Design	10.000	6.000	6.000	3.500

(U) This program is developing, characterizing, and demonstrating microelectronic design technologies to enable fabrication of radiation hardened electronic components using leading-edge, commercial fabrication facilities. The current mainstream approach for fabricating radiation-hardened electronics depends on specialized process technologies and dedicated foundries that serve this military market niche. While commercial semiconductor fabrication is not explicitly radiation hardened, recent trends in deeply scaled fabrication such as very thin oxides, trench isolation, and multiple levels of metal are resulting in semiconductor devices that are inherently more tolerant of radiation than older generations. This program is pursuing development of design-based technologies that will enable pure commercial fabrication technologies to attain radiation hardened electronics equivalent to those from the dedicated foundries. The design technology developed under the Radiation Hardening by Design Program is planned for transition to the Air Force and to the Defense Threat Reduction Agency (DTRA) at the end of Phase 2, which is anticipated to be completed by FY 2009. Specific design libraries for hardened circuits will transition through the defense electronics design industry, which are being supported largely by DTRA and the Air Force.

(U) Program Plans:

- Prove that a pure design-based approach will be capable of attaining radiation hardened electronic devices with less than one generation penalty in terms of device area, speed, and power.
- Create design libraries needed for implementing radiation hardened integrated circuits.
- Demonstrate the ability to design and fabricate a fully hardened complex circuit using developed design-based methodology and leading edge commercial fabrication facilities.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP)	7.000	8.000	11.000	11.000

(U) The Microsatellite Demonstration Science and Technology Experiment Program (MiDSTEP) program will develop the advanced technologies, capabilities, and space environment characterization required to demonstrate a suite of advanced lightweight microsatellite technologies integrated into high performance microsatellites across the continuum from low earth orbit (LEO) to deep space Super geosynchronous orbit (GEO) environment. The program will integrate a variety of advanced technologies, which have not been previously flight-tested, and may include: lightweight optical space surveillance/situational awareness sensors, lightweight power, chemical and electric propulsion systems, advanced lightweight structures, advanced miniature RF technology including micro crosslink and use of Commercial Off the Shelf (COTS) approaches, active RF sensor technology, COTS processor and software environment, miniature navigation technologies, including the use of starfields for deep space navigation, and autonomous operations. The developed capabilities may include high thrust, high efficiency solar thermal propulsion systems that can enable responsive orbit transfer as well as provide radiation resistant high density electrical power; ultra-stable payload isolation and pointing systems; and components to enable advanced miniature communication systems. The program will also consider affordable, responsive fabrication and integration approaches and the possibility of networking microsatellites/modules to create a flexible architecture of assets responsive to multiple missions and threats. If successful, MiDSTEP will demonstrate these technologies in space. The anticipated transition partner is USAF Space Command.

(U) The Microsatellite Technology Experiment (MiTeX) technology demonstration investigated and demonstrated advanced high-payoff technologies from a variety of potential candidates, including: lightweight power and propulsion systems, avionics, structures, commercial off-the-shelf (COTS) components, advanced communications, and on-orbit software environments. MiTeX flight tested a new, experimental upper stage, and demonstrated small COTS technologies to support a fast-paced, low-cost, lab-like, build-to-launch satellite approach in a shared industry/government environment.

- (U) Program Plans:
- Conduct system design trades of appropriate technologies.
  - Perform mission utility assessments and feasibility studies and develop concepts of operation.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

- Design and develop microsatellite system concepts and integrate selected technologies.
- Perform component and subsystem ground tests, fabricate and flight test microsatellite system.

	FY 2006	FY 2007	FY 2008	FY 2009
System F6	9.235	12.224	17.779	21.200

(U) The goal of System F6 program is to demonstrate a radically new space system composed of a heterogeneous network of formation flying or loosely connected small satellite modules that will, working together, provide at least the same effective mission capability of a large monolithic satellite. Current large space systems used for national security purposes are constrained due to their monolithic architecture. They can be launched only on a small number of large launch vehicles, cannot readily be upgraded and/or reconfigured with new hardware on-orbit, and are risk-intensive, since the unforgiving launch and space environments can result in a total loss of investment with one mistake. The System F6 will partition the tasks performed by monolithic spacecraft (power, receivers, control modules, etc.) and assign each task to a dedicated small or micro satellite. This fractionated space system offers the potential for reduced risk, greater flexibility (e.g. simplified on-orbit servicing, reconfigurability to meet changing mission needs), payload isolation, faster deployment of initial capability, and potential for improved survivability. This program will develop, design, and test new space system architectures and technologies required to successfully decompose a spacecraft into fundamental elements. Such architectures include, but are not limited to, ultra-secure intra-system wireless data communications, wireless power systems, electromagnetic formation flying systems, remote attitude determination systems, structure-less optical and RF arrays, and distributed spacecraft computing systems. The anticipated transition partner is the USAF.

- (U) Program Plans:
- Conduct system design trades of appropriate technologies and system architectures.
  - Perform mission utility and econometric-based value assessments and feasibility studies and develop concepts of operations.
  - Design and develop fractionated system concepts and integrate selected technologies.
  - Perform component and subsystem ground tests.
  - Fabricate and space test a microsatellite-scaled fractionated space system.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
Front-end Robotics Enabling Near-term Demonstration (FRIEND)	9.100	13.196	14.400	12.700

(U) The goal of the Front-end Robotics Enabling Near-term Demonstration (FRIEND) program is to develop, demonstrate and fly technologies designed to increase the survivability and operational effectiveness of geosynchronous (GEO) orbit-based military and commercial spacecraft. Existing GEO spacecraft are outfitted with sufficient propellant to provide for needed stationkeeping, repositioning, and retirement maneuvers, which in many cases defines their useful mission durations. Once this propellant is expended, the vehicle is retired and, in many cases replaced. FRIEND can enable significant service extension to these spacecraft through reboosting near end-of-life. FRIEND combines detailed stereo photogrammetric imaging with robotic multi-degree-of-freedom manipulators to autonomously grapple space objects not outfitted with custom interfaces. FRIEND offers the potential for spacecraft salvage, repair, rescue, reposition, de-orbit and retirement, and debris removal. The anticipated transition partner is USAF Space Command.

(U) Program Plans:

- Design, fabrication, and ground testing of the rendezvous sensor and robotic payload elements using flight hardware.
- Complete risk reduction lab test.
- Develop control algorithms for autonomous grapple and contingency operations.
- Procure and fabricate flight hardware for integration and testing.
- Conduct robotic payload ground test.
- Test control schemes in 1G environment.
- Conduct hardware-in-the loop testing in proximity operations test facility.
- Work with mission partner for full system integration and mission.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
X-ray Navigation and Autonomous Position Verification (XNAV)	5.200	3.550	0.000	0.000

(U) The X-ray Navigation and Autonomous Position Verification (XNAV) program sought to use periodic x-ray celestial sources to determine the three-dimensional position, attitude and time of orbiting spacecraft. XNAV explored the concept of operations (CONOPs) of a spacecraft equipped with an x-ray imager and photon counter to determine the feasibility and accuracy of x-ray pulsar sources for autonomous position, attitude, and time determination in low earth orbit (LEO) for DoD navigation and communication satellites.

(U) Program Plans:

- Determined x-ray detector sensitivity, response time, signal-to-noise properties, and timing electronics.
- Demonstrated expected navigation performance via detailed simulation.
- Catalogued properties of rotation powered pulsar sources for navigation.
- Developed preliminary x-ray detector system designs developed for the ISS Express Pallet.

	FY 2006	FY 2007	FY 2008	FY 2009
Fast Access Spacecraft Testbed (FAST)	0.000	4.300	7.000	9.000

(U) The goal of the Fast Access Spacecraft Testbed (FAST) program is to demonstrate a suite of critical technologies required to perform rapid orbital repositioning in the geosynchronous belt. A high-efficiency, high-power (50-80 kW), fast-transfer roaming satellite would permit on-demand access to any point on the geosynchronous ring or within the high-altitude, supersynchronous “graveyard” (where derelict systems are regularly repositioned in order to free up orbital slots within the ring), greatly improving our space situational awareness capabilities. The FAST demonstrator satellite, while possessing high power, would be revolutionary in its small size. At just 500 kilograms, the FAST spacecraft would carry a novel solar power collection and distribution system, composed of large-aperture (5-10 m diameter) concentrating mirrors, high-efficiency solar photovoltaics, and ultralightweight, deployable radiators, achieving specific power (watts/kilogram) levels an order of magnitude better than today’s state of the art. The anticipated transition partner is the Air Force.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

- (U) Program Plans:
- Conduct system design trades and investigate utility of applicable power and propulsion technologies.
  - Perform preliminary design and technology selection.
  - Perform detailed design and development of the FAST spacecraft, integrating selected technologies.
  - Fabricate, qualify, and launch the FAST spacecraft to a low earth orbit to demonstrate proof-of-concept.

	FY 2006	FY 2007	FY 2008	FY 2009
Tiny, Independent, Coordinating Spacecraft (TICS)	0.000	4.800	6.000	7.000

(U) The Tiny, Independent, Coordinating Spacecraft (TICS) program is intended to leapfrog the microsatellite revolution, not simply through downsizing but through the addition of advanced robotics technologies to allow satellites to reconfigure on demand, many times over during the course of a mission. TICS will develop key technologies to permit the delivery of small, difficult-to-detect nanosatellites (1-10 kg) into any common operational orbit, from low earth orbit (LEO) to geosynchronous orbit (GEO), with little or no advance warning. TICS could be hosted aboard “mothership” platforms in LEO or GEO, or could be delivered directly via ultra-light launch platforms. Such systems could perform rapid-response reconnaissance on any spacecraft, with times to mission orbit measured in just hours. Such systems would be composed of modular, dockable subassemblies that could autonomously modify their morphologies to become apertures, free-flying formations, crawlers, or booms, as dictated by mission need. A TICS aggregate will be capable of assembling, disassembling, dispersing, and subsequently re-assembling several times over. Enabling technologies include high-efficiency, miniaturized radar and active/passive optical sensors, multi-functional structures, software for advanced autonomous behavior (to include the ability to rendezvous, dock, undock, and formation-fly in multiple configurations), electric or chemical microthrusters, high energy density storage systems (including supercapacitors and advanced batteries), high efficiency energy conversion, and robust end effectors. The anticipated transition partner is the Air Force.

- (U) Program Plans:
- Conduct system design trades and provide “proof-of-concept” for a strawman TICS architecture.
  - Conduct preliminary design, analysis, and key technology demonstrations.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

- Perform detailed design and development of a TICS nanosatellite, integrating selected technologies and demonstrating aggregate behavior in a simulated space environment.

	FY 2006	FY 2007	FY 2008	FY 2009
NanoPayload Delivery (NPD)	0.000	0.000	4.000	8.500

(U) The goal of the NanoPayload Delivery (NPD) program is to validate the technical feasibility of ultralightweight, rapid-response spacecraft delivery from land, sea, or air-based platforms. Such nanopayloads (1-10 kilograms) could be boosted to low earth orbit (200 km altitude) in a matter of hours following call-up. Multiple sorties are envisioned, enabling a number of small spacecraft to be placed in an orbit “box” and aggregated together to perform a mission. The NPD program will develop and test a lightweight rocket platform similar in size to existing small missile systems such as the High-Speed Anti-Radiation Missile (HARM), AIM-7, or AIM-120. Current technology does not permit such small systems to reach orbit, owing to disproportionately high drag and low thrust-to-weight rocket engines. NPD will leverage ongoing technology development efforts, which permit the fabrication of microscale pumps, thrust chambers, and valves. Such rocket engines, which are theoretically capable of thrust-to-weight ratios of 100:1 or greater, would allow for significant reductions in overall engine mass and permit nanosatellites to be placed in low orbits for several weeks to months. The delivery system would rely on one of several methods for launch, including: (1) a stock aircraft, such as the F-15E or F-16, (2) a truck-mounted erector, or (3) the deck of a small naval vessel. The goal for per-sortie cost is \$100,000. Fielding NPD will permit U.S. forces to rapidly emplace short-term capabilities in low orbit, when they are needed, without resorting to legacy domestic launch systems that are sized and costed for much larger payloads. NPD will also allow many non-traditional users (e.g. laboratories, operational commanders, and small commercial firms) the capability to “use space” by lowering the significant barrier to entry into space. NPD will allow a streamlined, inexpensive approach to launch, descoping lengthy test and documentation requirements and demanding far fewer engineers, technicians, range personnel, and spacecraft operators per mission.

- (U) Program Plans:
- Survey existing aircraft-, land-, and sea-based missile platforms for compatibility with nanopayload delivery mission constraints and requirements.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

- Design, fabricate, and test an integrated micro chemical engine; including pumps, lines, valves, and thrust chamber; to validate performance models.
- Design, develop, and test arrays of micro engines for use as the first and upper stages of the NPD rocket platform.
- Integrate and test micro engine arrays on selected missile platforms.
- Perform aircraft-based launch demonstration of one or more nanopayloads.

	FY 2006	FY 2007	FY 2008	FY 2009
Space Situational Awareness & Counterspace Operations Response Environment	0.000	0.000	5.000	9.000

(U) The goal of the Space Situational Awareness (SSA) & Counterspace Operations Response Environment (SCORE) program is to develop and demonstrate an operational framework and responsive defense application to enhance the availability of vulnerable commercial space-based communications resources. SCORE will correlate a wide range of operational support and space system ground user data to rapidly identify threat activities, propose mitigating countermeasures, and verify the effectiveness of selected responses. Critical technologies include accessing disparate sources of relevant data, model-based situational awareness, and candidate response generation and evaluation. Particular emphasis will be placed on the ability to continuously adapt to changes in defended system components and usage patterns as well as validation of SCORE system integrity.

- (U) Program Plans:
- Develop initial system requirements and design.
  - Develop adaptive model of defended systems and identify relevant sources of data.
  - Conduct system trades and validate critical components.
  - Mature system parameters and operational procedures.
  - Demonstrate integrated system performance.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Space Programs and Technology PE 0603287E	

	FY 2006	FY 2007	FY 2008	FY 2009
Air Collection and Enrichment System (ACES)	0.000	0.000	5.000	10.000

(U) The Air Collection and Enrichment System (ACES) is an in-flight propellant collection system, which generates liquid oxygen (LOX) through the cryogenic separation of atmospheric air. Since it allows vehicles to take off without LOX on board—minimizing vehicle takeoff weight—the ACES technology is critical for Horizontal Takeoff, Horizontal Landing (HTHL) architectures to meet future launch vehicle safety, economic, and operational goals. The ACES enables reusable launch vehicles that operate with existing air-breathing and rocket propulsion systems to create a paradigm shift in space operations. The ACES program will build and test a palletized ACES system that can be proven on the ground and then flown on a test aircraft. This palletized system would use bleed air from the test aircraft to create rocket grade LOX. Successful completion would lead to a full scale flight demonstration of a Two Stage to Orbit (TSTO) system. This program will allow a TSTO aircraft to generate its own LOX onboard during flight, which will reduce the overall vehicle take off weight and allow more payload weight to be placed in orbit.

- (U) Program Plans:
- Develop and construct a boilerplate Rotating Low Pressure Column Fractional Distillation Unit (RFDU) capable of generating rocket grade LOX from aircraft engine or industrial compressor bleed air.
  - Modify RFDU hardware to improve efficiency and LOX purity.
  - Integrate ACES on a test aircraft and demonstrate LOX generation capability in flight.

	FY 2006	FY 2007	FY 2008	FY 2009
X-ray Communication in Space (XCOM)	0.000	0.000	2.000	5.000

(U) The X-ray Communication in Space (XCOM) program will develop a robust integrated communication solution to counter the potential for adversaries to disrupt or intercept secure spacecraft-to-spacecraft communication links to the warfighter. Specifically, XCOM will develop a novel x-ray modulator and detector with associated collimating optics for capturing photons at high signal-to-noise ratios and nanosecond timing

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E	

resolution. In addition, modulated signals from x-ray sources could simultaneously be used to perform relative navigation either as an x-ray beacon or in a two-way time transfer mode where on-board clock times are transmitted along the modulated two x-ray communication links in a form similar to microwave based two-way time transfer. Relative navigation based on this methodology has been estimated to be on the order of centimeters.

- (U) Program Plans:
- Demonstrate a low cost x-ray modulator; a high intensity x-ray source that can be tuned to specific energy bands (10 to 100 keV).
  - Demonstrate high timing resolution x-ray detector (< ns) to receive transmitted photons at data rates near 10 Mbits per second.
  - Integrate modulator and detector, demonstrate secure X-ray communications, and transition to military or intelligence user.

(U) **Program Change Summary:** *(In Millions)*

	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	216.357	254.913	294.648	317.360
Current Budget	210.736	253.950	224.551	225.238
Total Adjustments	-5.621	-0.963	-70.097	-92.122
Congressional program reduction	0.000	-0.963		
Congressional increases	0.000			
Reprogrammings	0.000			
SBIR/STTR transfer	-5.621			

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Space Programs and Technology PE 0603287E	

**(U) Change Summary Explanation:**

FY 2006                      The decrease reflects the SBIR/STTR transfer.  
 FY 2007                      The decrease reflects the reduction for Section 8106 Economic Assumptions.  
 FY 2008/2009              Decrease reflects the completion of the Orbital Express and ISAT programs.

**(U) Other Program Funding Summary Cost:**

Falcon	FY 2006	FY 2007	FY 2008	FY 2009
PE 0604855, Air Force SPC	23.354	16.000	0.000	0.000
PE 0604856, Air Force SPC	23.000	26.500	23.500	11.000
Deep View	FY 2006	FY 2007	FY 2008	FY 2009
PE 0305910F, Air Force SPC	18.511	0.000	0.000	0.000
PE 0305940F, Air Force SPC	0.000	13.576	8.859	0.709
Space Surveillance Telescope	FY 2006	FY 2007	FY 2008	FY 2009
USAF	0.000	0.000	0.000	1.100

**UNCLASSIFIED**

R-1 Line Item No. 33

Page 22 of 22

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development			R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E					
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Total Program Element (PE) Cost	197.318	243.728	220.548	232.383	220.481	160.813	155.351	155.351
Centers of Excellence MT-07	5.050	5.625	4.000	0.000	0.000	0.000	0.000	0.000
MEMS and Integrated Microsystems Technology MT-12	47.090	55.562	54.470	54.362	59.962	60.262	55.262	55.262
Mixed Technology Integration MT-15	145.178	182.541	162.078	178.021	160.519	100.551	100.089	100.089

**(U) Mission Description:**

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

(U) The Microelectromechanical Systems (MEMS) and Integrated Microsystems Technology project is a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems to address issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. The MEMS project has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure.

(U) The goal of the Mixed-Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems. These ‘wristwatch size’, low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E	

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.

(U) The Centers of Excellence project finances demonstration, training and deployment of advanced manufacturing technology at Marshall University.

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President’s Budget	220.877	248.627	236.675	225.765
Current Budget	197.318	243.728	220.548	232.383
Total Adjustments	-23.559	-4.899	-16.127	6.618
Congressional program reductions	-13.200	-11.424		
Congressional increases	0.000	6.525		
Reprogrammings	-4.700			
SBIR/STTR transfer	-5.659			

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E	

**(U) Change Summary Explanation:**

FY 2006	The decrease reflects the SBIR/STTR transfer, the Section 8040 rescission and the omnibus reprogramming.
FY 2007	The decrease reflects congressional cuts to Digital Control of Analog Circuits RF Front Ends, Analog Spectral Processors, ADNERF, High Gain Optical Transceiver on a Chip, Deep Ultraviolet Avalanche Photon Detectors, WIFI-EYEPOD, and a reduction for Section 8106 Economic Assumptions. These reductions are offset by congressional adds to Center for Advanced Microelectronics Manufacturing, Electronic Miniaturization, Enabling Ubiquitous Computing through Nanoscale Ultra-Low Power Electronics, and Mil-Tech Extension Technology Transition.
FY 2008	The decrease reflects completion of several efforts in Mixed Technology Integration Project (MT-15) including RF Front Ends, Ultra-Wide Band Technology, Liquid Electronics Advanced Power Sources and MEMS Electronic and Photonic Circuits in Silicon. These reductions have been partially offset by the continuation of the Advanced Manufacturing Technologies Center of Excellence.
FY 2009	The increase reflects exploration of new technologies in the MEMS and Integrated Micro-Systems Technology Project (MT-12) including Nano-Electro-Mechanical Computers and Microanalyzers.

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 47

Page 4 of 44

276

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Centers of Excellence MT-07	5.050	5.625	4.000	0.000	0.000	0.000	0.000	0.000

**(U) Mission Description:**

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University. The Byrd Institute provides both a teaching facility and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training emphasizes technologies to significantly reduce unit production and life cycle costs and to improve product quality.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Flexible Manufacturing	4.000	4.000	4.000	0.000

**(U) Program Plans:**

- Assess the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support.

	FY 2006	FY 2007	FY 2008	FY 2009
Defense Techlink Rural Technology Transfer Project	1.050	1.625	0.000	0.000

**(U) Program Plans:**

- Continue to provide funding for the Defense Techlink Rural Technology Transfer Project.

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07	

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
MEMS and Integrated Micro-systems Technology MT-12	47.090	55.562	54.470	54.362	59.962	60.262	55.262	55.262

**(U) Mission Description:**

(U) The Microelectromechanical Systems (MEMS) program is a broad, cross-disciplinary initiative to merge computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS applies the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale power and actuation systems as well as microscale components that survive harsh environments. The microfluidic molecular systems program will develop automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules to perform tailored analysis sequences to monitor environmental conditions, health hazards and physiological states.

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) mass data storage; 5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12	

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Micro Power Generation	4.207	4.030	3.000	3.000

(U) Compact portable power sources capable of generating power in the range of a few hundred milliwatts to one watt are critical to providing power for untethered sensors and other chip-scale microsystems. This program will replace today's technologies relying on primary and rechargeable batteries, which severely limit mission endurance and capabilities, by extending microelectronic machine technology to develop micro-power generators based on mechanical actuation and thermal-electric power generation. Operating with traditional fuels, these micropower generators will be capable of generating sustained power in the desired range for use with remote, field-deployed microsensors and microactuators. The program will also explore innovative micro-scale, integratable power sources to provide high-density energy sources. The Micro Power Generation program is anticipated to transition via industry to dismounted warrior and unattended ground sensor network programs under development by the Army.

**(U) Program Plans:**

- Demonstrated capabilities in fuel processing, energy conversion to electricity, and thermal and exhaust management.
- Demonstrated MEMS micro heat engines utilizing micropower sources.
- Demonstrate integration of various power-generation components with microsensors and microactuators.
- Demonstrate stand-alone, remotely distributed microsensors and actuators with built-in power supply and wireless communication.
- Establish design paradigm-shifts that occur when implementing novel power sources at the micro-scale using MEMS technology.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-12	

	FY 2006	FY 2007	FY 2008	FY 2009
Harsh Environment Robust Micromechanical Technology (HERMIT)	16.439	12.772	7.797	5.000

(U) The Harsh Environment Robust Micromechanical Technology (HERMIT) Program is developing micromechanical devices that can operate under harsh conditions- e.g., under large temperature excursions, large power throughputs, high g-forces, corrosive substances, etc. - while maintaining unprecedented performance, stability, and lifetime. Micromechanical RF switches are of particular interest, where sizable power throughputs and impacting operation constitute harsh operational environments. Other applications such as vibrating resonator reference tanks, gyroscopes, and accelerometers are also of interest. Among the HERMIT implementation approaches deemed likely to succeed are two of most interest: (1) wafer-level encapsulation or packaging strategies based on MEMS technology that isolate a micromechanical device from its surroundings while maintaining a desired environment via passive or active control; or (2) material and design engineering strategies that render a micromechanical device impervious to its environment, with or without a package (if possible). A key approach in this program that should allow orders of magnitude power savings is to selectively control only the needed micro-scale environment or volume via MEMS-enabled isolation technologies. The success of this program should enable a myriad of strategic capabilities including lower cost, more complex phased array antennas for radar applications; tiny frequency references with long- and short-term stabilities that greatly extend the portability of ultra-secure communications; and micro-scale inertial measurement units with bias stabilities approaching navigation-grade. The HERMIT program is anticipated to transition via industry to phased array antenna, reconfigurable communication front-end, seeker, and steerable aperture programs being developed by the Army, Navy, and Air Force, as well as to inertial navigation systems and Joint Tactical Radio System (JTRS) communications needed by these Services.

- (U) Program Plans:
- Establish the feasibility of encapsulating micromechanical devices under low-cost, wafer-level packages with minimal out-gassing or leaking and with minimal impact on device performance.
  - Demonstrate engineered materials and/or surface treatments that render a micromechanical device impervious to its surroundings or operating environment.
  - Demonstrate essential elements (e.g., thermistors, heaters, getters, etc.) needed for low power control of the operating environment surrounding a micromechanical device.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-12	

- Demonstrate micromechanical devices (e.g., RF switches, vibrating resonators, etc.) fully integrated together with environment isolating measures (including circuits, if any) that maintain unprecedented performance, stability, and reliability, even under harsh environments.

	FY 2006	FY 2007	FY 2008	FY 2009
Chip-Scale Micro Gas Analyzers	14.946	13.930	12.315	10.362

(U) The Chip-Scale Micro Gas Analyzer Program will utilize the latest MEMS technologies to implement separation-based analyzers (e.g., gas chromatographs, mass spectrometers, poly-chromator-like devices) at the micro-scale to greatly enhance the selectivity of sensors to specific species, and thus, enable extremely reliable, remote detection of chemical/biological agents. The use of MEMS technology should also increase analysis speed and make possible the operation of such complex analyzer systems at extremely low power levels-perhaps low enough for operation as autonomous, wireless sensors. The many challenges in this program include the exploration and realization of micro-scale preconcentrator approaches, stacked gas columns, multiple sensor arrays, ionizers, vacuum pumps, and vacuum packaging. The success of this program will yield sensors substantially more selective than conventional sensors, again, making them particularly suitable for detection and identification of airborne toxins. The Chip-Scale Gas Analyzers program is anticipated to transition via industry to Chemical Warfare Agents (CWA) detector programs being developed by the Defense Threat Reduction Agency (DTRA) and the Army Soldier and Biological Chemical Command (SBCCOM).

(U) Program Plans:

- Establish design trade-offs in (column) length vs. species separation efficiency for micro-scale gas chromatographs, mass spectrometers, resonator-based separation mechanisms, etc.
- Demonstrate MEMS-enabled, micro-scale preconcentrators and explore the degree to which they enhance separation efficiency and species detectability.
- Demonstrate MEMS-enabled, micro-scale separation columns, ionizers, electromagnetic field generators, vacuum pumps, gas sensor arrays, calibration sources, all needed for separation-based analyzers.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-12	

- Demonstrate advanced methods for making micromechanical sensor elements species sensitive (e.g., combinations of absorption spectroscopy and resonators coated with species-and-light sensitive films).
- Implement fully functional, MEMS-enabled gas separation analyzers with power consumptions small enough for autonomous, remote operation and control electronics integrated directly.

	FY 2006	FY 2007	FY 2008	FY 2009
MEMS Exchange	3.067	3.000	3.408	1.000

(U) This program seeks to provide flexible access to complex Microelectromechanical Systems (MEMS) fabrication technology in a wide variety of materials and to a broad, multi-disciplinary user base via the MEMS Exchange service. A major goal of the effort is to ensure self-sustained operation of MEMS Exchange after the end of the program by adding several process modules to the existing repertoire and increasing the number of processes run per year to raise revenues to the point of self-sufficiency. Among the future payoffs of this program is the establishment of an accessible infrastructure for low or medium volume production of MEMS-enabled products for DoD applications. The goal of the MEMS Exchange program is self-sufficiency at which point it will be able to provide MEMS fabrication services to all levels of industry and academia in support of Army, Navy, Air Force, and other DoD requirements without further DARPA sponsorship.

(U) Program Plans:

- Demonstrate online software capable of error checking and optimize process flow input by users to reduce the turn-around time per run and increase success rate.
- Insert a MEMS process module into the MEMS Exchange repertoire and make it available for use.
- Double the number of runs processed per year, to achieve a goal rate of 500 runs per year.
- Provide a modular merging process that combines modules together with transistor integrated circuits.
- Insert MEMS technology into three DoD applications using MEMS Exchange as the fabrication vehicle.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-12	

	FY 2006	FY 2007	FY 2008	FY 2009
Low Power Micro Cryogenic Coolers	4.930	4.730	3.950	6.000

(U) The Low Power Micro Cryogenic Cooler program will attain superior performance in micro-scale devices (e.g. Low Noise Amplifier (LNA's) IR detectors, RF front-ends, superconducting circuits) by cooling selected portions to cryogenic temperatures. The key approach in this program that should allow orders of magnitude power savings is to selectively cool only the needed volume/device via MEMS-enabled isolation technologies. Such an approach will benefit a large number of applications where performance is determined predominately by only a few devices in a system, e.g., communications where the front-end filter and LNA often set the noise figure; and sensors, where the transducer and input transistor in the sense amplifier often set the resolution. MEMS technology will also be instrumental for achieving micro-scale mechanical pumps, valves, heat exchangers, and compressors, all needed to realize a complete cryogenic refrigeration system on a chip. Transition of this technology is anticipated through industry, who will incorporate elements of the technology in current and future weapon system designs.

(U) Program Plans:

- Obtain high thermal isolation using MEMS technology, despite high surface-to-volume ratios of micro-scale elements.
- Demonstrate micro-scale compressors with sufficient efficiency for low power operation.
- Demonstrate heat exchangers, Joule-Thompson plugs, valves, pumps, all needed for cryo-cooler implementation.
- Integrate micro cooler components together with sufficiently isolated devices to-be-cooled to yield a single chip system.

	FY 2006	FY 2007	FY 2008	FY 2009
Chip-Scale Atomic Sensors	3.501	9.000	9.000	8.000

(U) The Chip-Scale Atomic Sensors program will develop universally reconfigurable microsensors (e.g., for magnetic fields, temperature, pressure) with unmatched resolution and sensitivity. These devices will use the latest in MEMS and photonic technologies to harness perturbations in atomic transitions as the sensing and measuring mechanisms for various parameters. Currently, some of our best sensors achieve their performance via readout mechanisms based on the frequency of mechanical resonators, which can be determined with high resolution. Chip-

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12	

scale atomic sensors would work on a similar principle, still using a time or frequency-based readout, but with substantially better resolution enabled by their much more stable atomic-clock-like readout. Furthermore, such sensors can be made reconfigurable by merely switching to atomic transitions that are strongly susceptible to certain stimuli, but insusceptible to others. If successful at achieving a universal sensor, the Chip-Scale Atomic Sensor program would not only provide sensors with unmatched performance, but would also be the key to lowering the cost of such sensors, since the production volumes for a universal sensor should be enormous. Interdisciplinary teams of fundamental technology developers and sensor integrators will be formed to transition the technology to DoD systems.

- (U) Program Plans:
- Develop a tunable microwave local oscillator to excite and select different hyperfine transitions.
  - Integrate sensing transducers into atomic cells.
  - Develop atomic cell wall coatings to mitigate the need for high cell pressure.

	FY 2006	FY 2007	FY 2008	FY 2009
Site-Specific Thermal Management (SSTM)	0.000	3.000	5.000	6.000

(U) The Site-Specific Thermal Management (SSTM) program will develop new approaches to removing local hot-spots that limit the performance of high-speed signal processing electronics, radar imaging systems, optoelectronic devices, and other systems characterized by above-ambient thermal issues. This program will provide a natural complement to the Low Power Micro Cryogenic Coolers program by addressing the performance-critical issue of excessive heat removal. The SSTM program will consider both monolithic and heterogeneous thermal management approaches based on variety of thermal materials and heat removal methods. Examples include self-powered liquid spray cooling, integral copper heat pipes, microfluidic channels and diamond interposer layers. This technology is lowering power consumption and overall cooling requirements and will be inserted through DoD industrial firms into future DoD systems.

- (U) Program Plans:
- Identify and apply new integrated technologies for the thermal management of microsystems.
  - Develop and integrate cooling approaches using new materials.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-12	

	FY 2006	FY 2007	FY 2008	FY 2009
Micro-Beam Clocks	0.000	4.000	5.000	7.000

(U) The Chip Scale Atomic Clock (CSAC) program (budgeted in PE 0602716E, Project ELT-01) will demonstrate the potential of shrinking high precision time references by exploiting advances in micromachining, photonics, and electronics technology. The Micro-Beam Clock program will extend the accuracy of miniature clock by exploiting the precision of nuclear particle transport. The concept of beam clock has been known at least since the 1960's but has not been widely pursued due to the difficulty in containing a large volume of xenon gas. This problem will be addressed by going to the micro-scale. Miniaturization of the conventional beam clocks with major innovations are possible due to microscale implementation – microscale xenon atom source, micromachined permanent magnets, and micromechanical atom flux detectors. This approach will not only improve the stability over existing CSAC but will further reduce the required power. This technology will be transitioned into DoD systems through innovative companies, including performers under the Chip-Scale Atomic Clock program.

(U) Program Plans:

- Generate sufficient atom flux using adsorption-desorption control at microscale.
- Detect atoms in flight using micro-cantilever array – Brownian noise limited.
- Determine permanent magnet laser cutting at microscale.
- Determine High B-field gradients at microscale.
- Determine pressure measurement in presence of high magnetic field with MEMS pressure sensors.

	FY 2006	FY 2007	FY 2008	FY 2009
Nano-Electro-Mechanical Computers (NEMS)	0.000	0.000	2.500	4.000

(U) The goal of this program is to develop nanoscale mechanical switches and gain elements integrated intimately with complementary metal-oxide semiconductor switches. One mechanical switch per transistor will enable the transistor to operate at near zero leakage powers, enabling pico or femtowatt standby operation. The program will also develop mechanical gain elements using physical effects such as giant

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-12	

magneto-resistance, buckling, electromechanical phase transitions, van der Waals forces, and Casimir forces to enable very low-noise, high-frequency amplifiers for low-power, low-noise analog signal processing. Possibilities of using mechanical power supplies and mechanical vibrating clocks could enable electronics that are less susceptible to electromagnetic pulse attacks. Enabling of nanomechanical elements in direct band gap materials will circumvent problems of gate oxide stability, allowing fast logic with optics functionality.

(U) Program Plans:

- Develop nanomechanical switch-based logic in semiconductors, metals and insulators.
- Develop mechanical gain elements for analog amplification using effects such as buckling and electromechanical phase changes.
- Develop NEMS switches in direct bandgap materials to enable optical functionality with switches.

	FY 2006	FY 2007	FY 2008	FY 2009
MicroAnalyzers	0.000	0.000	2.500	4.000

(U) The MicroAnalyzers program will apply recent developments in nanotechnology and MEMS to realize tiny, fast, ultra-low power liquid analyzers. Adopting a similar Micro-Gas Analyzers (MGA) theme of staged preconcentration, separation, and detection, MicroAnalyzers will develop MEMS sample collection and nanotechnology clean-up modules along with preconcentrators, separators, and chip-scale mass spectrometers specifically designed for liquids. Specific applications of these liquid analyzer efforts are: 1) rapid screening for trace contaminants in the water supply; 2) detection of water-born biological warfare (BW) agents; and 3) identification of trace chemical signatures associated with the manufacture of explosives and weapons of mass destruction (WMD).

(U) Program Plans:

- Develop compact, autonomous, deployable liquid analysis systems capable of identifying contaminants and toxins in water supplies, presence of Biological Warfare (BW) agents and chemical signatures associated with the manufacture and proliferation of explosives.
- Deploy remote collection of water samples.
- Sample clean-up and subsequent preconcentration of chemical substances of interest.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-12	

	FY 2006	FY 2007	FY 2008	FY 2009
Center for Advanced Microelectronics Manufacturing	0.000	1.100	0.000	0.000

- (U) Program Plans:  
 – Develop advanced microelectronics manufacturing processes.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Mixed Technology Integration MT-15	145.178	182.541	162.078	178.021	160.519	100.551	100.089	100.089

**(U) Mission Description:**

(U) The goal of the Mixed-Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems. These ‘wristwatch size’, low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. 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, fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration of mixed technologies to form batch-fabricated, mixed technology microsystems ‘on-a-single-chip’ or an integrated and interconnected ‘stack-of-chips’.

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

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

**UNCLASSIFIED**

R-1 Line Item No. 47

Page 17 of 44

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

technologies onto a single substrate will drive down the size, weight, volume, and cost of weapon systems while increasing their performance and reliability.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Digital Control of Analog Circuits (Formerly RF Front Ends)	0.542	2.500	0.000	0.000

(U) Digital Control of Analog Circuits will demonstrate analog/radio frequency (RF) electronic components that have the ability to self-assess and adapt in real time (sub microseconds), by self-tuning their impedance-matched networks and thereby extending the operational performance of analog components to the intrinsic semiconductor device limits. This technology will result in a new generation of analog, microwave and millimeter wave components with >150x improvements in power-bandwidth, linearity-efficiency products. This program will transition via industry in the form of integrated adaptive RF front-end components for a wide variety of applications used by the Services and intelligence agencies, particularly radar, space based communication, smart weapons, and electronic warfare systems.

**(U) Program Plans:**

- Demonstrate real-time active self-assessment and monitoring of RF/analog functions using nano-Complimentary Metal Oxide Silicon (CMOS) digital and mixed-signal technologies to achieve stability, signal agility, and multifunctionality.
- Design processes to fabricate arrays of molecular flow control devices including interconnect microfluidics and electronics.
- Develop techniques and algorithms to monitor active device status.
- Demonstrate MEMS tunable device optimization (<1 microsecond, 10:1 tuning ratio).
- Fabricate tunable MEMS control integrated circuits.
- Fabricate self-assessment control integrated circuits.
- Demonstrate device and algorithm concepts for intelligent self-assessment of analog functions.
- Demonstrate device concepts for 10<sup>5</sup> microsecond actuation time of impedance matched networks.
- Complete design concept for adaptable RF components.

**UNCLASSIFIED**

R-1 Line Item No. 47

Page 18 of 44

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- Demonstrate concept of digital assessment of analog device.
- Validate concept of adaptable RF components by demonstrating digital control of analog circuits.

	FY 2006	FY 2007	FY 2008	FY 2009
Optical Code Division Multiple Access (OCDMA)	6.380	0.000	0.000	0.000

(U) Optical CDMA represented a paradigm shift from the current Wavelength Division Multiplexing/Time Division Multiplexing (WDM/TDM) optical networks. Instead of assigning a wavelength and a time slot to a user, O-CDMA assigned a code to a user. The goal of this program was to demonstrate technology for an advanced O-CDMA communications system. Such a system potentially offered the benefit of multi-level security, low probability of interception, detection and jamming, decentralized network, and higher spectral efficiency. The O-CDMA program was anticipated to transition via industry to optical networking programs of interest to all Services.

(U) Program Plans:

- Demonstrated data transmission between 10 simultaneous users at 10 Gigabit/second per user with a low bit error rate.
- Demonstrated scalability to 100 simultaneous users and cardinality of 1000.
- Demonstrated spectral efficiency scalable to 1 bit/s-Hz.

	FY 2006	FY 2007	FY 2008	FY 2009
Large Area Distributed Macroelectronics	6.100	0.000	0.000	0.000

(U) The Large Area Distributed Macroelectronics program developed large area multifunctional actuation and sensing systems using novel combinations of active and passive electronics and flexible, conformable, non-traditional materials and techniques. It developed basic technologies and techniques for component attachment, electrical interconnections, and multilayer routing utilizing existing novel materials and designs for actuation and sensing such as electroactive polymers to achieve active porosity and fibers for acoustic response. The program demonstrated prototype systems that achieved orders of magnitude improvements in performance and/or cost. Examples of applications include:

**UNCLASSIFIED**

R-1 Line Item No. 47

Page 19 of 44

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

control surfaces for an autonomous precision guided parafoil and controlled air boundary layers for reduction in drag for underwater vehicles; beam steered acoustic arrays with large apertures to achieve order of magnitude improvements in angle of coverage and signal to noise ratios; early warning threat detection and localization using a large area inflatable structure with woven antennas and electronics for high bandwidth communications; and aircraft or UAV wing skins for chem/bio monitoring. This effort will transition through industry for active circuit applications.

- (U) Program Plans:
- Developed enhanced transistors compatible with low cost, large area fabrication.
  - Developed methods to print active circuits on large area and flexible circuits.
  - Developed techniques to wirelessly communicate between circuit blocks over a distributed electronics surface.
  - Developed novel circuit/microarchitectures to enhance system performance for demanding electronic applications.
  - Demonstrated examples of large area and/or flexible substrate distributed electronics to address difficult problems in sensor networks, physical security systems, or radar beam forming/steering.

	FY 2006	FY 2007	FY 2008	FY 2009
Adaptive Photonic Phased Locked Elements (APPLE)	9.546	11.512	10.000	9.000

(U) The goal of this program is to demonstrate a fully scalable and modular architecture of phased sub-apertures capable of producing an arbitrarily large optical aperture that can be rapidly and non-mechanically steered over a wide field of regard with high precision. This effort is anticipated to transition via industry for potential laser systems and space based applications.

- (U) Program Plans:
- Develop sub-apertures to operate at wavelengths of 1.06 um, 1.55 um, 3-5 um, and 8-12 um.
  - Demonstrate steering over a full 90-degree cone.
  - Reduce parts counts, which will make certain laser systems affordable.
  - Reduce weight, a particularly important goal for space-based applications.

**UNCLASSIFIED**

R-1 Line Item No. 47

Page 20 of 44

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- Develop and test a single APPLE aperture at the 50 watt optical power level.
- Introduce and verify a new material system for optical phased arrays and adaptive optical actuators to support the development path to higher power handling capability.
- Demonstrate by analysis the path to much lower loss electronic beam steering.
- Demonstrate by a combination of direct component measurements and advanced system modeling that an electronic beam control system, with optical loss of less than 2 dB, is feasible and supported by the development path.

	FY 2006	FY 2007	FY 2008	FY 2009
Data in Optical Domain Network (DoD-Network)	11.838	12.299	9.200	0.000

(U) Currently optical networks use photonics to transport data and electronics to process data. However, as the underlying bit rates of the optical networks are pushed beyond 40 giga-bits per second, there will be significant processing bottlenecks in these networks and these bottlenecks will severely limit the military's ability to rapidly transport time critical information. A potential solution to this problem is to develop photonic technology so optics can take over higher order network processing functions. The DoD-Network program will develop and demonstrate four key photonic technologies to meet these challenges: all-optical routing, all-optical data buffering (controllable and eventually random access), optical logic and circuits, and all-optical (multi-wavelength) regenerators. These photonic technologies will lead to intelligent all-optical networks. The program will have two major areas of interest: The first will focus on developing new photonic technology that is essential if photonics is to play a significant role in higher order processing in optical networks. The second area will focus on developing novel architectures that will fully exploit the new photonic technology to bring new and increased functionalities to the optical networks. The DoD-Network program is anticipated to transition via industry to high speed, high capacity optical networking programs of interest to the Air Force.

- (U) Program Plans:
- Develop a limited (4x4 or 8x8) optical packet switch.
  - Develop means for address processing.
  - Develop multi-wavelength optical regenerators.
  - Develop flexible, room temperature optical buffers.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- Develop synchronization techniques for short pulses.
- Develop controllable picosecond optical time delays.

	FY 2006	FY 2007	FY 2008	FY 2009
Microantenna Array Technology & Applications (MIATA)	8.645	7.117	0.000	0.000

(U) The goal of the MIATA program is to develop low-cost arrays that can sense both Millimeter Wave (MMW) and infrared (IR) scenes along with compact MMW designator sources for passive and active imaging applications in the spectral region from W-band (94 GHz) to the long wave infrared optical region. New micro- and nano-fabrication techniques of low cost antenna arrays provide a basis for revolutionary tactical military applications in the unexploited submillimeter to long wave optical spectral region. The military utility of this technology includes conventional passive imaging with compact devices at elevated temperatures, passive or active ballistic imaging through extreme weather and obscurants, polarization discrimination of manmade objects, rapid electronic spectral tuning for clutter discrimination, ultrawideband response (achieved using metal-insulator-metal tunneling structures for sensing/rectifying the antenna current), and may also include synthetic apertures, phased arrays, true time, and steered receiver beams. The MIATA program is planned for transition to the Army Research Laboratory at the conclusion of Phase 2, which is anticipated to be completed in FY 2007.

(U) Program Plans:

- Achieve 95 GHz: Noise Equivalent Temperature Detection (NETD)  $\leq$  20 Kelvin (K) in a 2x2 array.
- Achieve 8-12 um: NETD  $\leq$  0.1 K in an 8x8 array.
- Achieve 95 GHz: NETD  $\leq$  2 K in an 8x8 array.
- Achieve 8-12 um: NETD  $\leq$  0.02 K in a 64x64 array.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
Ultra-Wide Band Technology	17.239	10.500	0.000	0.000

(U) Radar array antennas that use the Ultra-Wide Band hold the promise of a new class of high coverage/high sensitivity systems. DARPA is tackling the issue through Ultra-Wide Band Multi-Function Photonic Transmit and Receive (ULTRA T/R) Modules.

(U) The objective of the ULTRA T/R program is to develop a wideband microwave antenna interface and corresponding antenna elements that would replace the conventional electronic T/R module-antenna combination and offer multiple modes of operation (e.g. simultaneous transmit and receive or switched mode), fiber interface to/from either digital or analog beamformer at significantly reduced size, weight, and power. The ULTRA T/R program is planned for transition to Navy and Air Force airborne C4ISR platforms and wideband phased-array antenna systems at the conclusion of Phase III, which is anticipated to be completed by FY 2007.

(U) Program Plans:

- Ultra Wide Band Multi-Function Photonic T/R Module
  - Develop and demonstrate optical modulators, which exhibit low switching voltages and incorporate a long effective electrode length.
  - Fabricate and demonstrate high power photodiodes and photodiode arrays for T/R modules.
  - Develop a high-efficiency, high-power, low Relative Intensity Noise (RIN) laser operating at 1550 nm.
  - Develop high antenna T/R isolation through a) low return loss at the modulator/antenna interface; and b) low mutual coupling between antenna elements.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
Laser-Photoacoustic Spectroscopy (L-PAS)	8.747	8.190	6.095	0.000

(U) The goal of this program is to develop and demonstrate highly sensitive, compact, rapid, reliable, inexpensive, and low power consuming chemical agent sensors based on the principle of laser photoacoustic spectroscopy. The L-PAS sensor will be able to discriminate a wide variety of possible chemical agents, explosives, and narcotics in the presence of diverse background environments. L-PAS will transition prototype chemical agent sensors to the Joint Science and Technology Office (JSTO), Defense Threat Reduction Agency, for evaluation. To that end, JSTO and DARPA are working closely to ensure that the final program metrics are properly aligned with the joint Chemical/Biological community needs.

(U) Program Plans:

- Demonstrate working prototypes that have a sensitivity to <1ppb at a false alarm rate of better than 10<sup>-6</sup>.
- Demonstrate a major improvement in performance (measured in terms of sensitivity) over the Joint Chemical Agent Detector (JCAD) system, which is the next generation chemical sensor currently under development.

	FY 2006	FY 2007	FY 2008	FY 2009
High Operating Temperature - Mid-Wave Infrared (HOT MWIR)	11.035	13.811	13.468	0.000

(U) The objective of this program is to establish technology for high-speed sampling and high spatial resolution infrared focal plane arrays that operate in the mid-wave infrared without cryogenic cooling. The high sampling speed is required for both threat detection and for imaging from fast moving platforms. Technology goals are to achieve greater than an order of magnitude reduction in currents contributing to detector noise demonstrated with a high density, large area detector array format of up to 1280 x 720 elements. For imaging, the sensor will respond in a broad spectral band, including the mid and long wave infrared, and optimized for imaging at high frame rates with large field of view. This program is anticipated to transition via industry for applications such as multi-band mid-wave or micro-detectors.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15	

- (U) Program Plans:
- Design new approaches necessary to reduce detector dark current and noise.
  - Amplify the low level signal in multi-band mid-wave detectors.
  - Develop micro-detectors, which collect signals from a large area while reducing the volume available for detector noise current generation.
  - Demonstrate carrier extraction techniques in the laboratory to show potential excess current while maintaining high signal levels.
  - Develop noise suppression techniques to solid state cooler design to reduce operating temperature without increasing power to the cooler.

	FY 2006	FY 2007	FY 2008	FY 2009
Liquid Electronics Advanced Power Source (LEAPS)	11.000	10.575	0.000	0.000

(U) This program will develop technology to support direct nuclear-to-electrical conversion in which a liquid semiconductor (LSMC) is used as a self-healing medium for capturing the energy of fission fragments in the form of electron-hole (e-h) pairs, and a collector of the e-h pairs. The liquid semiconductor will also serve as a medium in which to contain and disperse the nuclear fuel energy conversion. A general study of electronics based on liquid semiconductors will be included in this program. LEAPS is transitioning through industry teams involved in the manufacture of self-healing liquid semiconductor material and devices. These teams include technology vendors who intend to bring products to market as a result of this research.

- (U) Program Plans:
- Develop the liquid semiconductor-based nuclear source and reactor.
  - Implement a direct conversion cell using liquid semiconductor materials.
  - Develop liquid semiconductors as self-healing materials for high stress environments.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
Visible/Short Wave IR - Photon Counting	5.402	9.027	7.912	5.000

(U) This program will develop imaging over a broad spectral band at extremely low levels of ambient illumination to provide a unique capability for remote sensing, unattended sensors, and pay-loads for autonomous ground and air platforms. Recent innovations in solid state imaging devices, including parallel processing at the pixel level and novel read read-out technology, can contribute to development of a new class of sensors, which can create an image with only a few photons per pixel, exceeding performance of current low light level imagers. The direct conversion of low light level information into an electronic format provides access to a suite of signal processing, image enhancement and communications techniques not available with current low light level imaging devices. This program will transition via industry for ultraviolet to infrared imaging applications.

(U) Program Plans:

- Develop unique electronic read-outs with internal gain that boost low level signals above output amplifier noise.
- Develop potential approaches to include distributed amplification in the read-out signal chain, avalanche multiplier gain internal to the pixel, and semiconductor optical amplification integrated with the detector.
- Extend silicon detector response into the near infrared by doping with narrow band gap materials to achieve a single imaging chip with response from the ultraviolet to near-infrared.
- Integrate with uncooled long wavelength infrared imagers through development of technology to transfer the thin film silicon onto the infrared imager, achieving an imaging chip with broadband response and photon counting sensitivity from ultra-violet to the infrared.

	FY 2006	FY 2007	FY 2008	FY 2009
Electronic & Photonic Integrated Circuits on Silicon (EPIC)	17.428	12.970	7.223	5.000

(U) This program will develop two critical alternative photonic technologies based on silicon substrates. The first thrust addresses active photonic components based on silicon, which do not rely on generating light within the material. While passive photonic components, such as

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

waveguides, can be fabricated from silicon, silicon’s indirect bandgap does not lend itself to fabricating active photonic components based on the generation of photons (lasers, amplifiers etc.). The first alternative technology development will be optical amplifiers using Raman gain. Fiber amplifiers based on Raman gain currently play a major role in optical networks, and demonstrating this optical amplification in silicon will be a major step toward overcoming on-chip losses in complex chip-scale optical components. The second alternative technology development will address optical transistor action, or switching, in silicon, (i.e., a three-terminal optical device in which control photons at one terminal will make a large change in the photons transmitted between the other two terminals). Taken together, these two capabilities will create a new paradigm in which silicon will provide a platform for monolithic integration of photonic and electronic functions. The EPIC program is anticipated to transition via industry to optical communication and electronic warfare programs of interest to all Services.

(U) Program Plans:

- Demonstrate low-loss waveguides connecting optical gates and increased dynamic range for the logic gates.
- Demonstrate integrated processing functions such as adders and shift registers, requiring integration of 3-10 logic gates.

	FY 2006	FY 2007	FY 2008	FY 2009
Space, Time Adaptive Processing (STAP) BOY	4.356	6.240	4.240	0.000

(U) This program will research, develop, and demonstrate miniature, low-power, low-cost, teraflop-level signal processing solutions derived from commercial Graphics Processor Unit (GPU) hardware and software of the type currently used for fast geometry computations in hand-held electronic games like Nintendo’s GAME BOY®. Success in this program will allow the DoD to exploit the continuing phenomenal growth in both performance and programmability of GPU’s resulting from competition in the multi-billion dollar international electronic entertainment industry. Particularly relevant advantages of recent GPU’s over more traditional embedded processors include enhanced memory access bandwidth, hardware-accelerated floating-point vector geometry functions, low power consumption, and open source programming language support. The STAP BOY technology is planned for transition to the Army at the conclusion of Phase III, which is anticipated to be completed in FY 2008.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- (U) Program Plans:
- Develop and characterize a prototype architecture using a single GPU and a Field Programmable Gate Array (FPGA) input-output structure.
  - Demonstrate that the prototype system is capable of sustaining 100 Gflops potentially scalable to a multi-GPU pipeline mesh teraflop computing architecture, and is easily programmable to provide extremely high performance in diverse challenge problems.
  - Demonstrate the single GPU prototype consisting of 1) adaptive algorithm for data structure simplification, suitable for adaptive weight computations in STAP and 2) 3-D tomographic reconstruction processing for aperture synthesis.

	FY 2006	FY 2007	FY 2008	FY 2009
Vertically Integrated Sensor Arrays (VISA)	8.270	11.000	7.000	6.000

(U) The Vertically Integrated Sensor Arrays (VISA) program addresses new architectures for three-dimensional focal plane arrays, where multiple levels of signal processing are integrated into each pixel in the array. This novel infrared focal plane architecture will be expanded to include multiple processing layers, higher density “vias” at the pixel, and coverage of a broad spectral band from the visible to the infrared. This increased on-chip processing power will enable new capability for smart sensors, such as high speed imaging, on-chip threat discrimination and anti-jamming. The VISA technology establishes a dramatically new approach to read-out electronics for imaging sensors, impacting multiple areas essential to Defense systems. The three-dimensional read-out architecture allows increased on-chip charge integration, dynamic range of eighteen to twenty bits, simultaneous registration of multiple wavelength bands, and high speed laser imaging. Specific system impacts include Mid/Long-wavelength target acquisition systems for air and ground; smart missile seekers, and anti-jamming, and imaging through high intensity sources. This program will transition through parallel efforts involving industry, universities, and other not for profit organizations to develop vertical interconnect techniques and novel read-out architectures and circuits to be incorporated in DoD systems.

- (U) Program Plans:
- Demonstrate high dynamic range imaging sensors with an analog to digital converter at each pixel in the array.
  - Design and develop three-dimensional focal plane architecture with multiple levels of signal processing at each detector in the array.
  - Develop thru-via and interconnection technology with greater than 99% operability on 256x256 arrays.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- Demonstrate increased sensitivity realized by the large charge storage capacity of the three-dimensional focal plane circuit architecture.
- Develop low mass structures and high-Q resonators.
- Develop nanoparticle mass-load tags for enhanced sensitivity.

	FY 2006	FY 2007	FY 2008	FY 2009
Analog Spectral Processors	0.000	4.500	8.483	9.979

(U) The Analog Spectral Processors (ASP) program will leverage existing MEMS capabilities to make precision RF components, and perform low-insertion-loss/heterogeneous components integration to demonstrate integrated Analog Spectral Processors that greatly reduce dynamic range and bandwidth required on A/D converters and other front-end components. This will enable proliferation of advanced RF capabilities to the individual war fighter by dramatic reduction in size, weight, and power of RF systems. Industrial firms that are currently the major suppliers of radio equipment for defense and homeland security applications will serve as the primary transition partners upon successful completion of the program.

(U) Program Plans:

- Demonstrate large scale heterogeneous integration of MEMS resonators, MEMS switches, and RF active components to enable Analog Spectral Processor Front-Ends capable of arbitrarily sampling across at least three decades of bandwidth and dynamically compressing spectrum in terms of bandwidth and dynamic range so as to present only signals to the Analog Digital Converter.
- Demonstrate filter arrays.
- Demonstrate ASP.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
All-Dielectric Non Electronic RF Front-End (ADNERF)	0.000	3.500	5.000	6.500

(U) The All-Dielectric Non Electronic RF Front-End (ADNERF) program will create a wide bandwidth, tunable RF front end technology that is immune to electromagnetic pulse attack. This program will seek an entirely new approach to RF front-end technology where all metal and front-end electronic circuitry are eliminated. Of particular interest will be an all-dielectric, electronics-free RF front end with sensitivity and dynamic range consistent with today’s wireless communication and radar systems. By eliminating the metallic antenna, a secondary goal is to effect a significant reduction in detectable radar cross section.

(U) All-Dielectric, Non-Electronic RF Front Ends (ADNERF) represent the ultimate solution for protecting wireless communication and radar systems. ADNERF can find immediate application protecting tactical communication and radar systems, which are highly vulnerable to electromagnetic pulse (EMP) attack due to their close proximity to enemy assets. As the efficiency and tunability of the all-dielectric non-electronics front-ends improve, the technology can become an ubiquitous RF front end for all military as well as commercial wireless devices, providing the communications infrastructure immunity against EMP attacks. This program will transition through industry performers involved with reducing the susceptibility of electronics to damage from high electro-magnetic pulse weapons.

(U) Program Plans:

- Identify and develop innovative dielectric materials with high dielectric constant and low loss.
- Design and implement doubly resonant (RF and optical) antenna structures in support of non-electronic signal transduction.
- Demonstrate dramatic reduction in RF front end susceptibility to electromagnetic pulses while maintaining militarily useful system.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
High Gain Optical Transceiver on a Chip	0.000	3.500	6.000	7.500

(U) The High Gain Optical Transceiver on a Chip program will address development of an ultra-compact, low power, solid state laser transceiver-on-a-chip (source and receiver), achieving with integrated circuit technology, the peak energy and narrow pulse width required for high resolution imaging. Two technical innovations will contribute to this new capability, large arrays of vertical cavity surface emitting lasers (VCSEL) integrated into a micro-chip; and the incorporation of high gain at receiver, specifically semiconductor optical amplifiers integrated with the detector to boost the laser signal return above receiver noise. The high optical gain at the receiver will add flexibility to trade-off laser power for solid state optical gain, and the capability to illuminate targets with extremely low optical power, providing a nearly-covert optical signal. Wavelength diversity augments the capability to illuminate difficult to detect optical signals.

(U) Currently, diode pumped lasers will require high peak energy to achieve 20 to 100 mj with the narrow pulse width (1 – 10 nsec) needed for imaging and targeting applications. These laser systems will be dramatically simplified with solid state arrays and have the potential to reduce size of these lasers from several pounds to a few ounces while at the same time significantly increasing overall efficiency to as high as 80%. The solid state arrays avoid the efficiency loss in coupling optical energy into the gain medium, and eliminate conversion loss in the gain medium as well. This program will transition through industry performers into DoD systems by putting laser illuminating imaging into the hands of individual warfighters, allowing integration into small robotic platforms and micro-air vehicles.

(U) Program Plans:

- Achieve the extremely high peak power required for imaging and targeting applications via design, integration, and packaging.
- Re-design VCSEL arrays to achieve the closed packaged density consistent with compound semiconductor manufacturing.
- Demonstrate high peak energy per pulse at narrow pulse width, which requires both design and processing innovations to realize the interconnection of thousands of individual elements, while achieving the rapid response necessary for narrow pulses.
- Demonstrate improvements in individual device design specifically tailored for pulse mode operation that are necessary to achieve the high peak power required for imaging and ranging applications, which include novel cavity materials, reflective layers, spacing.
- Achieve thermal stability via device mounting and heat sinking.

**UNCLASSIFIED**

R-1 Line Item No. 47

Page 31 of 44

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- Develop complementary process for the semiconductor optical amplifier.
- Develop array compatible semiconductor optical amplification technology to achieve gain at the detector with the resolution required for imaging.
- Amplify low level optical returns with minimum excess noise while maintaining uniformity across the array.

	FY 2006	FY 2007	FY 2008	FY 2009
Maskless Direct-Write Nanolithography for Defense Applications	0.000	24.000	21.000	24.000

(U) This program will develop a maskless, direct write lithography tool that will address both the DoD’s need for affordable, high performance, low volume Integrated Circuits (ICs) and the commercial market’s need for highly customized, application-specific ICs. In addition, this program will provide a cost effective manufacturing technology for low volume NanoElectroMechanical Systems (NEMS) and Nano Photonics initiatives within the DoD.

(U) Maskless lithography tools, installed in the Trusted Foundry and in commercial foundries, would enable incorporation of state-of-the-art semiconductor devices in new military systems, and allow for the cost-effective upgrade of legacy military systems.

(U) Program Plans:

- Develop a maskless, direct write lithography tool that will address both the DoD’s need for affordable, high performance, low volume ICs and the commercial market’s need for highly customized, application-specific ICs.
- Determine a cost effective manufacturing technology for low volume NanoElectroMechanical Systems (NEMS) and Nano Photonics initiatives within the DoD.
- Enable incorporation of state-of-the-art semiconductor devices in new military systems, and allow for the cost-effective upgrade of legacy military systems.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
Stand-off Detection and Identification	0.000	6.000	8.000	6.000

(U) The Stand-off Detection and Identification program will detect and identify explosive threats at a stand-off distance, which is critical to force protection in all military operations, especially in urban scenarios. Multiple techniques will be available for detection, but no single technique provides both high probability of detection with low false alarm rate, and identification of specific characteristics of the threat. A micro-system approach with multiple, synergistic sensor technologies integrated in a compact package, will be critical to wide spread deployment of this sensor capability.

(U) The microsystem approach involves the identification of significant attributes from multiple non-over-lapping perspectives, such as shape and chemical signature, at stand-off ranges of fifty meters to potentially one hundred meters. This presents major challenges in imaging through opaque media; identifying signatures in parts per billion in high background ambient; selecting specific wavelength bands of interest; and the signal/imaging processing required for positive identification. The system configuration presents additional integration challenges for potential application in manportable systems or small autonomous vehicles. This program will transition through industry performers into DoD systems aimed at developing stand-off x-ray imaging devices for robotic vehicles.

(U) Program Plans:

- Develop unique imaging techniques suited to imaging through visually opaque objects at a 50-100 meter stand-off distance.
- Investigate multiple imaging approaches including integration of typically disparate techniques such as passive infrared and radio frequency with active techniques, laser imaging and high energy active imaging techniques, x-ray imaging.
- Implement x-ray imaging and develop compact package for remote vehicle applications. X-ray source requirements, such as power, size, weight, focal spot, tube configuration including various beam formation techniques must be investigated to efficiently transmit radiation over the stand-off distance. Source requirements will be traded-off for more efficient sensor technology, notably two dimensional arrays of cadmium telluride or silicon carbide with high spatial resolution.
- Identify particular effluents, which requires development of unique spectrometer-on-a-chip sensor concepts that cover a broad spectral range.

**UNCLASSIFIED**

R-1 Line Item No. 47

Page 33 of 44

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- Investigate excitation sources and tunable sensors from the far-infrared through millimeter wave spectral regions.
- Address issues including efficient radiation coupling into the sensor, spectral selectivity, signal enhancement techniques.

	FY 2006	FY 2007	FY 2008	FY 2009
Deep Ultraviolet Avalanche Photon Detectors	0.000	3.500	4.597	5.302

(U) Recent advances in Wide Bandgap Semiconductor materials have opened new possibilities for exploiting the ultra-violet region of the electromagnetic spectrum. The current Semiconductor Ultra Violet Sources (SUVOS) program has been successful in advancing the state of the art of Ultra Violet (UV) light emitting diodes and laser diodes. This follow-on program seeks to develop high sensitivity, compact ultra violet detectors. Specifically, avalanche photodiodes will be developed to detect single photons. These UV detectors will dramatically improve the performance and reduce the size and weight of the biological warning detectors under development in the SUVOS program. They will also increase the range and data rate of covert UV communications systems. This program will transition through industry and university performers developing compact, reliable, and cost-effective photodetectors for a variety of military applications.

(U) Program Plans:

- Develop high sensitivity, compact ultra violet detectors.
- Develop avalanche photodiodes that can detect single photons.
- Improve the performance and reduce the size and weight of the biological warning detectors under development in the SUVOS program.
- Reduce the defects by orders-of-magnitude and develop highly doped cladding layers.
- Optimize the detector response and switching speed.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
WIFI-EYEPOD	0.000	3.000	4.860	7.240

(U) The WIFI-EYEPOD program will transform the dismounted soldier into a semi-autonomous Direct Current (DC) - 10 GHz sensor/comms/SIGINT platform using a personal digital assistant (PDA) modified with a broadband multifunctional RF sensor plugged into its universal serial bus (USB) port. Combined with the current DARPA STAP-BOY program, or even a standard laptop, the RF-EYEPOD enhancement will enable real-time local processing for extremely time-sensitive and perishable data requiring immediate processing and response. The WIFI-EYEPOD RF sensor may be used to control and or hunt near field enemy WIFI and communications networks allowing the soldier to virtually see enemy combatants communicating and setting up attacks, hiding behind walls and in buildings mixed with non-combatants. Working in small networks will permit instantaneous location(s) of sniper fire and gunfire for retribution, and positions of tactical squad members relative to inside and outside of buildings, without detection by enemy sensors.

(U) In addition to adding RF-sensory and networking capability to PDAs and vehicle-mounted information processing hardware, the WIFI-EYEPOD will provide secure communications and networking capability so that the processed information can be compressed and downloaded real-time to larger, holistic sensor integration systems, providing micro-detail to create macro understanding at the unit and division command levels. Transition targets are through Army PM Soldiers Systems and USMC ground forces.

(U) Program Plans:

- Develop, integrate and optimize diverse system capabilities into a single low cost miniature package with a cost target at less than \$1 thousand per unit.
- Optimize commercial integrated circuits in wideband digital synthesizers, and custom high dynamic range Analog/Digital Converters and digital filters into a mixed-signal Analog Signal Integrated Circuits using the latest processes in SiGe and 90nm CMOS.
- Integrate a modem, quad-band antenna, and Ultra-Wide Band (UWB) antenna and transmitter with commercial interface to create an embedded processing unit.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
MEMS Electronic & Photonic Integrated Circuits in Silicon	10.000	5.000	0.000	0.000

(U) This program will provide new systems capabilities for integrated RF microsystems by developing material and device processing technologies for integrating microelectromechanical RF structures (MEMS) with integrated RF/microwave/millimeterwave (MMWAVE) electronics to form reconfigurable, multi-functional active RF surfaces. The integration of massive numbers of miniaturized MEMS structures with advanced control and RF processing will enable fully programmable metallic and active RF processing surfaces, which will be capable of rapid reconfiguration under electronic control to adapt their resonant and out-of-band characteristics, creating new classes of components that can rapidly and efficiently span electromagnetic bands with high signal-to-noise ratio and minimal losses. These highly integrated active RF elements will consist of efficient, low loss, low power, agile transceivers with high speed digital RF memories, precision analog/mixed signal circuits, and MEMS sensors and structures for actively reconfiguring the resonant structures and devices. This technology will transition through the electronics industry performers and eventual DoD systems utilizing this integrated microelectromechanical RF technology.

(U) Program Plans:

- Develop and demonstrate fabrication technologies for critical high performance electronics and micromachined components with very high quality factors and high performance radio-frequency characteristics compatible with integration into active radio frequency surfaces.
- Develop and demonstrate chip and device-scale electromagnetic isolation approaches.
- Complete development of scaled fabrication process for reducing power and insertion loss of integrated radio-frequency components.
- Complete measurements of radio-frequency parameters of integrated radio-frequency components and perform de-embedding analysis.
- Demonstrate integration technologies that result in the ability to combine high speed analog/mixed signal electronics with digital control devices and with micromachined devices to form active surfaces for agile radio-frequency microsystems.
- Develop control algorithms for controlling the active electronics and micromachined components across wide dynamic range and bandwidth for active radio-frequency surface applications.
- Complete far-field and power measurements of fully programmable radio-frequency active surface microsystem.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
Airplane on a Chip (AOC) - Chip Scale Avionics	0.000	0.000	3.000	5.000

(U) The Airplane-on-a-Chip (AOC) program seeks to exploit continued advances in integrated Microsystems technology to remake the stovepipe/legacy avionics architecture present in modern aircraft. The fundamental goal of the program is to deliver an avionics system approaching one cubic centimeter in volume and dissipating 10s of milliwatts of power, compared with 10s of cubic centimeters (best case) and 10s of Watts of power in contemporary systems. The program will bring together advances in Chip Scale Atomic Clocks, Navigation Grade Integrated Micro Gyroscopes, 3-Dimensional Electronics, Compressive Sensing, Chip Scale Wavelength Division Multiplexing, and Robust Integrated Power Sources, to name only a few, to revolutionize avionics for the 21<sup>st</sup> century. It is expected that such advances will revolutionize airframe design and capability by delivering more functionality at lower power in a smaller volume, enabling distributed avionics for enhanced survivability and increase autonomous operation.

(U) Program Plans:

- Develop advanced integrated microsystems technologies for avionics guidance, navigation, and control that exploit progress in Chip Scale Atomic Clocks, Navigation Grade Integrated Micro Gyroscopes, 3-Dimensional Electronics, Compressive Sensing, Chip Scale Wavelength Division Multiplexing, and Robust Integrated Power Sources.
- Deliver an avionics system approaching one cubic centimeter in volume with power dissipation on the order of 10s of milliwatts.

	FY 2006	FY 2007	FY 2008	FY 2009
Nanophotonics for Ultradense On-chip Communications	0.000	5.000	8.500	12.000

(U) The goal of the Nanophotonics for Ultradense On-chip Communications program is to demonstrate nanophotonic technology for (1) access to on-chip ultradense systems and (2) I/O to/from a chip containing such ultradense systems. Technical challenges that must be met include: high precision, low loss nanophotonic circuit fabrication, low cost fabrication methods, high performance nanoscale modulators, detectors, multiplexers and demultiplexers, architecture for addressing ultradense systems, techniques for efficient high capacity/bandwidth I/O of

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15	

data to and from the chip. This technology will transition via industrial performers developing everfaster and more complex processing such as real-time pattern matching, target recognition, image processing and THz class command-and-control networks.

- (U) Program Plans:
- Demonstrate high performance, low power active and passive photonics at ~ 1 mm size-scale for on-chip global interconnects for significantly improved processor performance.
  - Demonstrate seamless interface between intrachip and ultra dense capacity off-chip communication utilizing nanophotonic components.
  - Investigate novel processor architectures enabled by increased interconnect speed and density available from photonics.

	FY 2006	FY 2007	FY 2008	FY 2009
Hemispherical Array Detector for Imaging (HARDI) - Electronic Eye	0.000	5.000	8.000	12.000

(U) The objective of the Hemispherical Array Detector for Imaging (HARDI) program (formerly Electronic Eye) is to exploit the benefits of the hemispherical imaging surface. The basic idea behind the program is that a detector array can be fabricated on a hemispherical substrate using materials such as organic/inorganic semiconductors and that this array can be combined with a single lens to produce a wide field of view, small form factor camera. Organic materials have been shown to have good electronic and optoelectronic properties including light emission and detection. Furthermore, in-plane organic/inorganic transistors can be incorporated for pre-processing of images. This program will transition to eventual DoD systems through a demonstration of an array prototype developed by industrial contractors.

- (U) Program Plans:
- Develop high quantum efficiency semiconductor materials for photo-detection in the 400-1900 nm range that can be deposited onto curved surfaces.
  - Develop modeling to predict optimum materials and device performance.
  - Develop technology to deposit pixel control circuitry onto a curved surface.
  - Develop processes to fabricate 20 micron a side pixels on a curved surface with 80% fill factor.

**UNCLASSIFIED**

R-1 Line Item No. 47

Page 38 of 44

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- Develop methods to integrate read-out circuitry to focal plane on a hemispherical surface.
- Fabricate a 1024 x 1024 pixel focal plane array on a 1 cm radius hemispherical curved surface.
- Evaluate focal plane array architecture with ray tracing programs such as Zemax.

	FY 2006	FY 2007	FY 2008	FY 2009
Day/Night Adaptive Imager	0.000	0.000	3.000	9.000

(U) Low light level imaging has proved its value in providing the individual warfighter with the tactical advantage to see first in crucial night imaging scenarios. With widespread use of low light level technology, a new paradigm in low light level imaging is necessary to maintain these distinct advantages and provide new capability beyond current imaging technology. The new approach is the noiseless detection and processing of individual photon events, which leverages the benefits of solid state imaging and takes advantage of three dimensional signal processing architecture at the detector. By detecting an image formed from individual photon events without the addition of excess noise, the image can be processed and manipulated to provide the user image information not possible with current sensors.

(U) Programs Plans:

- Develop ultra wide dynamic range imaging sensors that count individual photon events and also operate in high light level.
- Reduce dark counts for room temperature operation.
- Demonstrate integrated functions, such as day / night imaging with covert signal detection.

	FY 2006	FY 2007	FY 2008	FY 2009
Miniature, Room Temperature, Ultra-sensitive Magnetic Sensor	0.000	0.000	3.500	10.500

(U) The goal of this effort is to develop a micron scale, room temperature magnetic sensor with detection sensitivity at least comparable to that of a Superconducting Quantum Interference Device (SQUID). The device would also require low power and be produced with standard micro-

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

fabrication processes. Recent work in organic materials that preserve electron spin coherence over tens to hundreds of nanometers and also in atomtronics suggest that room temperature ultra sensitive magnetic sensors are achievable.

(U) Program Plans:

- Determine specific metrics and requirements for applications of ultra-sensitive (sub-pico tesla), room temperature magnetic sensors with performance comparable to that of a SQUID device but without cryogenic operation.
- Fabricate and optimize device architectures with half-metal/organic semiconductor/half-metal sandwich structures at sub-mm scales and evaluate magnetic field sensitivity.
- Engineer organic semiconductors for optimum spin injection, spin coherence length, spin-orbit and hyperfine interaction.
- Develop optimum processes for device fabrication to enhance magneto-resistance and reduce noise in presence of earth's magnetic field.
- Determine device performance as a function of temperature and frequency.
- Develop theoretical modeling and simulation to evaluate potential to achieve sensitivity comparable to that of SQUID devices without cryogenic operation.
- Fabricate multiple devices to determine yield, stability, and robustness.

	FY 2006	FY 2007	FY 2008	FY 2009
Contiguous Multi-Mega-pixel Infrared Imaging Arrays	0.000	0.000	3.000	7.000

(U) This program will address the development of large arrays for persistent surveillance with the objective of developing technology for multi-mega-pixel pixel arrays with integral signal and image processing. Since contiguous coverage over large areas is essential, approaches will be developed to construct extremely large array assemblies from smaller arrays without loss of lines at the intersection between arrays. A new array architecture will be designed to integrate electronic overhead functions, such as synchronization clocks, power bias lines and ground connections in a three dimensional structure directly under the active pixel array. This design leverages and extends the emerging three dimensional signal processing technology and establishes a technology base for large contiguous array assemblies, not possible with current

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

infrared arrays. Approaches also will be developed for the assembly of multiple infrared arrays on non-planar surfaces in order to realize practical optical designs for large arrays.

- (U) Program Plans:
- Develop approaches for contiguous butting of large infrared arrays without line loss at array intersection.
  - Demonstrate large multi-color arrays with integral data pre-screening to highlight potential targets and areas of interest.

	FY 2006	FY 2007	FY 2008	FY 2009
High Resolution Short Wave Infrared	0.000	0.000	3.000	10.000

(U) This program will address emerging material growth and deposition technology with the potential to produce extremely high resolution, high density short wave detector arrays. Growth approaches to be investigated include infrared quantum dots, which can be deposited directly from a solution, molecular beam epitaxy, and epitaxial growth onto selected areas of the silicon read-out. The growth techniques must be optimized to produce films with high optical absorption, and uniform film characteristics consistent with deposition over large areas. Electrical contact to small size detector elements also will be addressed. Approaches must be developed to form the electrical contact between small area detectors and input to low noise preamplifiers on the silicon substrates.

- (U) Program Plans:
- Develop material growth and array processing for extremely high-resolution short wave infrared with pixel size on the order of the wavelength.
  - Develop new detector approaches for high pixel density with passivation processes to control surface leakage, which will dominate small detectors.
  - Demonstrate test structures with detector size approaching 2 microns and show contact method to small pixel structure.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
Control of Optical Properties of Infrared Semiconductors	0.000	0.000	3.250	10.000

(U) This program seeks to electronically control the optical emission from infrared semiconductor material in infrared material and devices with pay-off in several new areas important to Defense Systems. The equilibrium level of electronic charge carriers in a semiconductor material can be controlled by the applied bias, altering optical emission at the surface. In a light emitting diode, electronic injection of excess charge into a semiconductor stimulates radiation emission. Analogously, the extraction of charge carriers suppresses radiation emitted from the sample. In the infrared spectral region, radiation emitted from a semiconductor defines the apparent temperature of the material. Control of the apparent temperature of infrared material has direct application in radiation shielding for room temperature detectors, covert communications and marking targets in the infrared. Radiation shielding in room temperature imager has the potential to increase sensitivity five to ten times expanding the application base of room temperature infrared imagers.

(U) Program Plans:

- Demonstrate detection of modulated signal with zero average using existing 3-5um NL material.
- Reduce Long-Wave Infrared (LWIR) dark current and material doping by X10.
- Investigate growth of LWIR material on silicon substrates for larger area, lower cost and longer range.

	FY 2006	FY 2007	FY 2008	FY 2009
Micro-Systems Thermal Management	0.000	0.000	3.750	11.000

(U) The objective of the Micro-Systems Thermal Management Program is to develop a new class of devices using a concurrent design approach to develop isothermal chips with the requisite electrical characteristics and thermal management designed into the device. The goal is to increase the heat dissipation rate allowing the design of high power conversion and motor drive systems to be reduced by approximately 1/3. This will significantly reduce the system size and complexity required to increase warfighting capability in smaller, lighter, more reliable and affordable radar power conditioning systems, power conversion and motor drives and avionics.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Advanced Electronics Technology PE 0603739E, Project MT-15	

- (U) Program Plans:
- Synthesize nano-scaled materials with the requisite electronic and thermal characteristics.
  - Integrate devices into a power module with a 1/3 reduction in design complexity.
  - Increase the rate of heat dissipation from 100W/cm<sup>2</sup> to 10kW/cm<sup>2</sup>.

	FY 2006	FY 2007	FY 2008	FY 2009
Electronic Miniaturization	5.100	2.800	0.000	0.000

- (U) Program Plans:
- Develop novel techniques for miniaturization of electronic components.

	FY 2006	FY 2007	FY 2008	FY 2009
Small Scale Systems Packaging	1.000	0.000	0.000	0.000

- (U) Program Plans:
- Developed new approaches for packaging of small electronic components.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Lithography Fabrication Processing	2.550	0.000	0.000	0.000

- (U) Program Plans:
- Developed new fabrication processing technology in lithography systems.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development		R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15	

	FY 2006	FY 2007	FY 2008	FY 2009
Enabling Ubiquitous Computing through Nanoscale Ultra-Low Power Electronics	0.000	1.000	0.000	0.000

- (U) Program Plans:  
 – Develop nanoscale low power electronics for defense applications.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	207.852	227.626	256.868	267.786	275.154	268.154	270.154	270.154
Command & Control Information Systems CCC-01	47.285	50.732	68.396	78.961	87.200	86.200	86.200	86.200
Information Integration Systems CCC-02	100.255	100.275	85.123	83.825	83.495	88.495	90.495	90.495
Classified CCC-CLS	60.312	76.619	103.349	105.000	104.459	93.459	93.459	93.459

**(U) Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

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

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

**UNCLASSIFIED**

R-1 Line Item No. 51

Page 1 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E	

<b>(U) <u>Program Change Summary:</u> (In Millions)</b>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	213.316	232.489	238.395	245.796
Current Budget	207.852	227.626	256.868	267.786
Total Adjustments	-5.464	-4.863	18.473	21.990
Congressional program reductions	0.000	-4.863		
Congressional increases	0.000			
Reprogrammings	0.000			
SBIR/STTR Transfer	-5.464			

**(U) Change Summary Explanation:**

FY 2006	The decrease reflects the SBIR/STTR transfer.
FY 2007	The decrease reflects congressional program reductions to PANDA, XG and WNaN and a decrease for Section 8106 Economic Assumptions.
FY 2008/2009	The increases reflect additional funding in Project CCC-01 to transition cognitive systems technologies to operational Command, Control and Intelligence (C2I) systems and minor repricing of classified efforts, offset by a decrease in Project CCC-02 following transition of several communications efforts in FY 2007.

**UNCLASSIFIED**

R-1 Line Item No. 51

Page 2 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>						DATE February 2007		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Command & Control Information Systems CCC-01	47.285	50.732	68.396	78.961	87.200	86.200	86.200	86.200

**(U) Mission Description:**

(U) Military operations since the end of the Cold War illustrate that current theater-level command, control, communications, and intelligence/information systems lack the ability to fully support operations in complex, time-critical environments. Warfighters must be prepared for operations ranging from conflict and peacekeeping in urban centers to heavy battle actions in remote areas. Current capabilities do not provide the commander with real-time, secure, situational awareness or the ability to orchestrate high-tempo planning, rehearsal, and execution. The programs in this project are developing and testing innovative, secure architectures and tools to enhance information processing, dissemination, and presentation capabilities. The programs provide the commander insight into the disposition of enemy and friendly forces, a joint situational awareness picture that will improve planning, decision-making, and execution support capability, as well as secure multimedia information interfaces and software assurance to the warfighter “on the move.” Integration of collection management, planning, and battlefield awareness are essential elements for achieving battlefield dominance through assured information systems.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR)	9.178	10.178	12.532	8.761

(U) The Joint Air/Ground Operations: Unified, Adaptive Replanning (JAGUAR) program will improve battle management for complex air campaigns that employ new air platforms featuring precision sensors, weapons and communications relays. The JAGUAR system is driven by: 1) targeting information, both for sensor targets and strikes, expressed as point and area targets (i.e., search, combat air patrol); 2) rules of engagement and procedural constraints, such as airspace restrictions; and 3) availability of platforms, weapons, sensors, and communications equipment. From this information JAGUAR produces ingress routes, flight schedules and patrol zones, while assuring airspace and electronic deconfliction. The technology provides pilots and commanders the option to choose conventional tactics or conceive unconventional operations.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

In the latter case, the system captures the innovation and retains the strategic maneuver for future mission plans. JAGUAR monitors actual plan execution against expected results and alerts commanders to significant differences. The technology captures statistical descriptions of small differences to help assess the robustness of future plans. There is a Memorandum of Understanding in place with the U.S. Air Force and technology transition is planned to occur in FY 2009.

(U) Program Plans:

- Equip a training facility with software tools and human observers to capture plans as constructed, executed, and modified.
- Conduct exercises and capture a large set (several hundred) of mission plans as example cases.
- Decompose each plan into plan fragments.
- Assemble groups of related plan fragments into plan templates.
- Develop a large-scale integration algorithm to assemble plan fragments into a synchronized operational plan.
- Build optimization tools to tailor routes, schedule events, and deconflict airspace and radio frequencies.
- Compile standard mission plan products from the optimized operational plan.
- Demonstrate tools to correlate actual field events to planned events.
- Evaluate these techniques in periodic training events.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Ground Tactical Battle Manager	7.605	6.133	8.000	10.000

(U) The Advanced Ground Tactical Battle Manager program is developing automated decision support tools for Army and Marine tactical commanders at the division level and below. The program also provides support for combined operations employing dismounted soldiers, manned platforms, and autonomous vehicles. The tool will elicit skeletal courses of action through a graphical interface with unit commanders and extend plans by applying adversarial reasoning techniques to identify vulnerabilities and opportunities in the predicted enemy course of action. Finally, modifications or counteractions will be developed to reduce vulnerabilities. Products will transition to the Army.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

- The Know What Is to Know Subsystem (KWIKS) will develop a support tool that autonomously and continually, during the execution of a military operation, tracks the state of what is known about the environment (and how well), and what are the forms and priorities of additional collection needs. This tool will provide substantially automated assistance to the current (laborious and non-real-time) process of collections planning, which currently includes manual steps such as analysis of external context, enemy and neutral goals and capabilities, and assessment of known threats. The overall benefit would be more effective, rapid, complete identification of enemy state, resulting in achieving mission objectives with fewer friendly casualties and lower collateral damage.
- The Deep Green subsystem combines anticipatory planning with adaptive execution, providing military decision makers with capabilities on the battlefield that the IBM computer 'Deep Blue' brings to the chessboard. This effort will explore closed-loop simulation to integrate planning, execution, and will incorporate continuous learning. The technology will also employ software agents to monitor the execution of the current operation against the plan, identify variations as the scenario unfolds and consistently explore the possible future states of the battlefield. This technology will allow a proactive rather than reactive stance in the command of the battlefield giving the U.S. warfighter the advantage.

(U) Program Plans:

- KWIKS
  - Extend and develop emerging computational techniques for analysis of information state under conditions of adversarial concealment and deception and partial observability.
  - Design and develop a system compatible with needs of service users and leveraging existing and emerging data sources.
  - Design and execute a series of realistic wargame-based experiments to enhance and validate the capabilities of the system.
  - Adapt and validate the system for transition requirements.
  - Integrate into existing information infrastructures.
- Deep Green
  - Extend prediction horizon further into the future.
  - Include concealment and deception behaviors in predictions.
  - Build interfaces to existing and future Army intelligence and command and control systems.
  - Continue to conduct experiments to ascertain the value of the tools.

UNCLASSIFIED

R-1 Line Item No. 51

Page 5 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

- Construct an architecture that allows interleaving anticipatory planning and adaptive execution.
- Develop and enhance a state-space representation and new algorithms to identify courses of action.
- Create and enhance planning agents to develop and assess enemy and friendly courses of action and execution monitoring agents to help identify when the plan is going awry.
- Develop technologies that enable systems to learn how the enemy fights and to update both predictive analysis tools and behavior modeling in simulation (to include models of aggressive and timid enemy behaviors as well as hypothesized potentially deceptive behaviors).

	FY 2006	FY 2007	FY 2008	FY 2009
Predictive Battlespace Awareness	3.046	2.258	5.000	6.000

(U) The Predictive Battlespace Awareness program develops tools to interactively draw upon a distributed network of human experts, allowing them to collaboratively anticipate an opponent’s future actions. The program will enable commanders to pre-position sensors, weapons, and information to counter the opponent’s actions. The program will develop model- and knowledge-based techniques to predict areas of operation and tactical objectives. The technology will support the modeling of courses of action ranging over time horizons from hours to days. Program techniques permit “on-the-fly” tailoring of models and contextual knowledge, and leverage knowledge of sensor effectiveness, mobility factors, tactical templates, and target characteristics. Techniques to be developed include variable-fidelity prediction, such as the ability to determine both target locations over minutes and force zones of influence over hours. The tools anticipate enemy operations in time to thwart them with effects-based targeting, enabling use of sensors and other resources in proactive modes. The program will both enable commanders to avoid canned responses and support rapid incorporation of insights about new enemy strategies, capabilities, and tactics from peacetime to the heat of battle. The program will significantly enhance today’s mostly manual, slow planning, and analysis processes. Technologies are planned to be transitioned to the Air Force Distributed Common Ground Station.

- (U) Program Plans:
- Develop new algorithms for locating and tasking distributed human experts with portions of a problem to be solved.
  - Construct sophisticated monitoring and assimilation algorithms that ensure the distributed human experts are making progress, re-task as necessary, and assimilate results to form a cohesive report for the requesting party.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

- Define a set of realistic challenge problems, including scenarios and a simulation facility to illustrate the context and value of predictive battlespace awareness.
- Develop approaches to prediction that combine physics-based modeling (e.g., for mobility and observability) with knowledge-based techniques (e.g., plan generation or recognition).
- Evaluate alternative approaches against the challenge problems.
- Define a system architecture that combines the best approaches into a consistent, mutually supporting toolkit.
- Integrate selected technologies into the toolkit.

	FY 2006	FY 2007	FY 2008	FY 2009
Comprehensive Force Protection	3.943	0.000	0.000	0.000

(U) The Comprehensive Force Protection program developed a rapidly deployable system to provide assured protection of permanent or temporary U.S. base camps in hostile territory. The system included wide-area sensors and platforms to maintain continuous surveillance of the camp area to detect potential intruders and weapon launches. The program also included a suite of airborne sensor platforms that can be tasked rapidly to investigate potential threats or “lock on” to personnel or weapons involved in an attack. Data collected from sensors is automatically analyzed, correlated, and provided to commanders to confirm threats and authorize precision weapons to engage. The system maintains continuous perimeter surveillance, allows rapid investigation, and, when authorized, attacks threats.

- (U) Program Plans:
- Collected data on realistic intrusions in a variety of weather conditions.
  - Characterized the performance of candidate signal processing, target recognition and localization, and environment monitoring algorithms on the test data.
  - Selected a set of algorithms for a baseline system build.
  - Constructed and calibrated a system performance model for the selected algorithms.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Urban Commander	13.025	11.727	13.998	12.146

(U) The Urban Commander thrust develops automated tools to help ground commanders construct detailed, realistic operational plans, particularly in nontraditional and urban environments. Partial plans are represented in hierarchical task networks and visualized through synchronization matrices, icon overlays, or tactical sketch animations. Commanders and staff modify, refine, and extend a plan through voice, sketching, and semi-structured input. The system links fragments constructed at different sites, transfers information among related parts, and discovers and recommends solutions for inconsistencies. The system continuously compiles a set of plan cases and employs analogical matching to propose extensions to current plans suggested by past experience. Plan elements are communicated through an integrated set of protocols from the unit commander down to dismount commanders equipped with advanced heads-up displays and helmet-worn sensors. Finally, the program continuously assesses progress against the operational plan and alerts users to significant deviations.

- The Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS) program develops, integrates, and demonstrates a soldier-worn visualization system. Both helmet-mounted and handheld versions will be built during Phase 3 of the program. The system consists of five elements: 1) multi-spectral sensor suite; 2) high resolution digital display; 3) inertial measurement unit (IMU); 4) high-speed processor; and 5) power supply. MANTIS provides the warfighter with digitally-fused imagery in real time from the multi-spectral sensor suite, exploiting three distinct spectral bands: 1) the Visible/Near Infrared (VNIR, .4 - .9 microns); 2) the Short Wave Infrared (SWIR, 1 - 2 microns); and 3) the Long Wave Infrared (LWIR, 8 - 12 microns). The fused imagery is shown on two displays; one has a wide field-of-view and the other a narrow field-of-view. When viewed together the system furnishes a larger field-of-view image with simultaneous high resolution and stereo capability. The system also allows the warfighters to record and “play back” the video while on the battlefield. The record/playback feature includes: electronic zoom, scroll, pan and panoramic image stitching. MANTIS provides a vision-aided inertial navigation system (INS) and will interface with the future soldier’s global positioning system (GPS). When combined with precise pose estimation from the helmet-mounted IMU, MANTIS allows battlefield information to be overlaid on the display to provide increased situational awareness. MANTIS interfaces with the future soldier’s advanced communications and networking systems, allowing the warfighter to send/receive video images and position information with fellow soldiers and commanders in real time. The coupling of the imaging system with INS/GPS will provide the individual warfighter a “point-click-kill” capability for real-time target hand-off capability to networked smart weapons fired from remote locations, thereby significantly increasing the lethality of the individual

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

warfighter. There is a Memorandum of Agreement in place with the Program Executive Officer Soldier, and Night Vision & Electronics Sensor Directorate for transition at the conclusion of Phase III anticipated to be completed early in FY 2008.

- The ULTRA-VIS program will develop an integrated system to provide Army and Marine small unit leaders with the ability to conduct daytime operations in an urban environment. Key technologies will be developed to significantly improve the awareness, lethality and survivability for small units in urban combat. The system will include a conformal, see-through, optical waveguide visor that displays intra-squad commands, alerts, and even icons that are attached to the urban landscape. Network protocols will be developed for information management that allows the squad leader to hand-off actionable information and direct alerts to the squad /fire teams for real-time collaboration without overload. ULTRA-VIS will relay standard phrases and visual annotations that can be issued covertly, avoiding hand signals or shouting that may be recognized by the enemy. A robust, optically-assisted navigation technique will provide continuous geo-location and head tracking for each squad member while operating in GPS-denied environments. The ULTRA-VIS system will synthesize weapon fire observables across a networked moving squad to detect and locate hostile weapon fire using a helmet mounted IR sensor and small acoustic array for precise sniper location and real time designation within the warfighter’s visor. ULTRA-VIS will empower the small unit leader with a clear tactical advantage through inter/intra squad collaboration, heightened awareness and the ability to take decisive action while on-the-move. The ULTRA-VIS technology is planned for transition to the Army.
- An urban warfare environment presents the warfighter with limited sightlines and mobility with insufficient knowledge of the disposition of enemy combatants, civilians, and occupied structures. As a result, the warfighter requires situational awareness information, presented in a manner that accounts for current operational context and personal strengths, limitations, and preferences. The Urban Commander program develops planning and control tools to support dismounted troops equipped with MANTIS and ULTRA-VIS sensors and displays. “On-the-ground” warfighters do not have time to constantly check an information rich visual display. Cognitive Impedance Matching (CIM) technology will develop a prototype system for presenting the information at the correct time and format to the affected individual. The system will ensure that situational awareness will be obtained and maintained across a range of echelons and battlefield conditions. Urban Commander forms a command and control substrate that enables ground forces, including vehicles and dismounts, to rapidly coordinate actions as the situation and commanders knowledge of the situation change. The program includes: 1) spatial analysis to determine lines of sight and fields of fire; 2) planning aids to assist in sensor placement and route planning; 3) visualization tools to allow commanders and soldiers to rapidly apprehend and address a situation; and 4) analysis tools to suggest locations and types of

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

potential threats. Urban Commander Technologies are planned to transition to the Army Program Executive Office Command, Control, and Communications Tactical (PEO C3T).

(U) Program Plans:

- Multi-spectral Adaptive Networked Tactical Imaging System (MANTIS).
  - Evaluated/demonstrated multi-sensor imagery and processing capability via MANTIS testbed.
  - Completed functional prototype design.
  - Fabricate three MANTIS functional prototypes (two helmet-mounted, one handheld) for evaluation.
  - Conduct independent laboratory/field tests of MANTIS prototypes.
  - Transition to the US Army (PEO Soldier).
  
- Ultra-VIS
  - Develop see-thru display conformal visor using holographic waveguide.
  - Develop optically-assisted navigation for continuous geo-location and pose estimation.
  - Develop interface to actuate non-verbal commands and post icons onto a shared urban landscape.
  - Create network protocols for alerts and information management for inter-squad collaboration.
  - Develop fusion algorithms to precisely locate weapon fire using IR and acoustic signatures within a moving networked squad.
  - Integrate technology components into an end-to-end system and demonstrate full system capabilities for military evaluations.
  
- Urban Commander
  - Defined a common plan representation, based on service training material, for combined arms operations and constructed an initial collection of operational plans, for many scenarios and force structures.
  - Developed multi-modal presentation of situation awareness data, utilizing visual, auditory, haptics, and other presentation modes.
  - Develop new interfaces for presenting content rich information in a compact format and operational languages.
  - Construct protocols to propagate changes generated at one location to affected locations, in accordance with defined policy and build flexible algorithms to match changes received from remote locations to the aspects of a plan retained locally.
  - Demonstrate detection of plan inconsistencies and recommend corrections and conduct a series of laboratory evaluations with Army and Marine commanders to assess the quality and utility of program products.

UNCLASSIFIED

R-1 Line Item No. 51

Page 10 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

- Develop an architecture based on the concept of a tactical global information grid (T-GIG), a service-oriented architecture that provides adaptive user filtering at the GIG side (not the user side) for information delivery, fault tolerant mechanisms, and controlled filter propagation.
- Develop a context aware system, incorporating sensors and software to detect the warfighter's operational conditions and current cognitive state, and to detect if the warfighter has incorporated the situation awareness data that has been presented.
- Incorporate additional tools for presenting and understanding situation awareness, including mapping and line of fire tools.

	FY 2006	FY 2007	FY 2008	FY 2009
Heterogenous Urban Reconnaissance Team (HURT)	7.220	5.782	5.000	4.000

(U) The Heterogeneous Urban Reconnaissance Team (HURT) initiative develops integrated tactical planning and sensor management systems for heterogeneous collections of unmanned platforms operating in urban environments. HURT employs a model-based control architecture with dynamic teaming and platform-independent command and control. The system registers new platforms with the battle manager (kinematics, maneuverability, endurance, payloads, and communications links) to facilitate platform-independent tasking. HURT provides a commander's interface that allows collaborative tasking of the platforms in the form of operational missions, such as search, track, identify, or engage, rather than routes and events. Additionally, it supplies computationally intensive decision aids, such as advanced 4D airspace and groundspace deconfliction tools, route planners, and task/platform assignments algorithms. The technology presents mission status and future courses of action to commanders for collaborative adjudication. HURT enables augmentation of low-footprint, rapidly deployable, easily sustainable human command structures with teams of machines operating together. HURT technology is planned for transition to the United States Marine Corps, U.S. Special Operations Command, and Air Force Special Operations Command.

- (U) Program Plans:
- Selected a baseline planning/control algorithm.
  - Developed a centralized information management server.
  - Define multi-user reconnaissance missions.
  - Assess the ability of the planning/control algorithms to effectively use each platform.
  - Conduct field tests at an urban warfare training facility.

**UNCLASSIFIED**

R-1 Line Item No. 51

Page 11 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Tactical Group Decision Analysis Support System	3.268	4.329	5.812	7.000

(U) The Tactical Group Decision Analysis Support Systems program will develop distributed group decision analysis and network management tools. These tools will increase the tempo of the tactical commander’s observe-orient-decide-act loop, the quality of decisions, the contribution of data point input across the organization, and the necessary communications capabilities needed to support this decision structure. This effort will develop a set of tools to evaluate risks and identify optimal “network configuration pivot points,” and ideally will automate specific configurations for each network element. The Command, Control, Communications, and Computers (C4) tool suite provides the warfighter with a reliable communications network, which is critical to successful military operations. The tools will be applied in crisis management situations for tactical commanders and could be transitioned to existing emergency response command and control systems as well as emerging tactical command and control systems. The technologies developed under this program are planned for transition to the Army.

(U) Program Plans:

- Develop novel data structures and algorithms to exploit as many individual contributions as possible to a group decision problem in order to provide a comprehensive and well-founded automated decision.
- Create distributed infrastructure and user interface mechanisms to support real-time group decision analysis without the need for expert facilitators/participants to be in the same place at the same time.
- Provide a capability for continuous tracking of real-world events as well as stakeholder revisions related to the decision, to alert the tactical commander when the decision that was made is no longer optimal.
- Develop prototype decision analysis systems and validate that these systems lead to more effective decision making.
- Perform analysis of requirements for C4 capabilities including contingent event specification and network requirements representation.
- Refine and scale strategies for automating the configuration reasoning tasks for future C4 networks.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Dynamic Airspace Allocation	0.000	2.500	4.000	7.000

(U) The goal of the Dynamic Airspace Allocation program is to maximize airspace utilization through dynamic military airspace management. Today’s labor-intensive human centric airspace management processes result in an inefficient use of airspace and limit the density and responsiveness of airborne systems. The program will evaluate and develop technologies for an automated system that efficiently manages all objects in the airspace to include munitions, manned aircraft, and unmanned air vehicles. The automated system will be developed as a replacement for current processes and will support all service users. Challenges to be addressed include maintaining real-time position and kinematic information for all objects in the airspace and the development of algorithms to dynamically reallocate airspace without human involvement. The capabilities developed by this program will benefit all of the services.

- (U) Program Plans:
- Develop and simulate potential system architectures.
  - Develop a preliminary design for the system.
  - Demonstrate critical technologies.
  - Develop and test a prototype system.

	FY 2006	FY 2007	FY 2008	FY 2009
Predictive Analysis for Naval Deployment Activities (PANDA)	0.000	7.825	11.054	15.054

(U) Predictive Analysis for Naval Deployment Activities (PANDA) develops technology to automatically learn normal activity models (motion and emission) for maritime surface vessels, automatically detect anomalous behavior, provide context modeling to resolve known categories of anomalies (e.g., due to weather and business rule changes), and alert processing. The resulting technology can be extended and applied to a wide range of applications including ground vehicles, troop movements, and individual targets of interest (e.g., suspected insurgents),

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

as the methods of tracking those targets improves. The initial application will be anomaly detection in the maritime domain. PANDA technologies are planned to transition to the Office of Naval Intelligence and the Fleet Commanders.

- (U) Program Plans:
- Develop new technologies and system architectures to support distributed learning of activity pattern models from complex spatio-temporal, all-source data.
  - Demonstrate that individual and class-of-vessel motion-based activity patterns can be learned and used to detect anomalies.
  - Use patterns to predict movements and classify (groups of) vessels as potentially (non) hostile with a low incidence of false alarms.
  - Learn and detect multi-ship correlated activities.
  - Incorporate context models.
  - Leverage detection/tracking capabilities to include large and small (harbor) vessels.

	FY 2006	FY 2007	FY 2008	FY 2009
Increased Command and Control Effectiveness (ICE)	0.000	0.000	3.000	9.000

(U) The Increased Command and Control Effectiveness (ICE) program will develop and incorporate cognitive systems technology into operational Command, Control, and Intelligence (C2I) systems within each service. DARPA’s Cognitive Systems programs have been developing the machine learning, reasoning, and human-machine dialogue technologies necessary to create cognitive assistants. This new technology promises to enable information systems to adapt – during deployment, in real time – to the changing conditions that military commanders confront. Information systems will automatically adjust to new environments and new users, helping commanders adapt to evolving situations and priorities, and accelerating the incorporation of new personnel into command operations. This program will fund the portions of the technologies developed in the Personalized Assistant that Learns (PAL) program (funded in PE 0602304E, Project COG-02) that are ready for application to command and control systems.

(U) From an operational perspective, cognitive approaches to information processing offer three major enhancements to current command and control systems. First, it will efficiently sort, segregate, separate and identify relevant data based on priority hierarchies established by the command structure. For example, image data could be selected based on target priority, historical context or anomalous changes. Second,

**UNCLASSIFIED**

R-1 Line Item No. 51

Page 14 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

cognitive technologies can adapt the presentation of information to suit the needs and preferences of the individual commander. Finally, cognitive systems will make relevant data generally available to all users both during collaborative planning processes and individual tactical analysis. In short, cognitive technology is introducing the equivalent of “just in time” inventory management to information management for command decision-making.

(U) The Army’s Command Post of the Future (CPOF), the Navy’s Composeable FORCENet (CFn) and the USAF’s Air Tasking Order (ATO) information systems with the Air Operations Center (AOC), have been identified as target systems for the application of this new cognitive systems technology. These systems support complex situation assessment and decision making, process massive data streams and require users to integrate uncertain and dynamically changing information. They represent a spectrum of potential needs and constraints and taken together will assure that cognitive systems technology is of general applicability and utility throughout the military. Cognitive assistants will enable users to handle additional tasks as well as tasks of greater complexity. This will ultimately reduce the staffing footprint of command centers.

(U) Program Plans:

- Develop an initial prototype of a cognitively-enhanced CPOF system.
- Field test and refine the initial cognitively-enhanced CPOF prototype to validate that the cognitive technologies are robust to the dynamics and uncertainties associated with real use in an operational setting.
- Develop an advanced prototype of a cognitively-enhanced CPOF system that would learn to anticipate users’ information needs, to pre-fetch needed information, to coordinate teams, and to manage message traffic.
- Field test and refine the advanced cognitively-enhanced CPOF prototype to validate that the cognitive technologies are robust to the dynamics and uncertainties associated with real use in an operational setting.
- Develop an initial prototype of a cognitively-enhanced Air Tasking Order (ATO) information systems with the Air Operations Center (AOC).
- Field test and refine the initial cognitively-enhanced Air Tasking Order (ATO) information systems with the Air Operations Center (AOC).
- Develop an initial prototype of a cognitively-enhanced Composeable FORCENet (CFn).
- Field test and refine the initial cognitively-enhanced Composeable FORCENet (CFn).
- Develop new concept of operations as necessary to support the deployment of cognitively-enhanced information systems.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-01	

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Information Integration Systems CCC-02	100.255	100.275	85.123	83.825	83.495	88.495	90.495	90.495

**(U) Mission Description:**

(U) The goals of the Information Integration Systems project are to take diverse data inputs from a variety of sources, efficiently disseminate the information, and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base. Through the use of wideband dissemination and integrated sensor management, the project will also facilitate multi-site, real-time, collaborative situation assessment and course-of-action evaluations to enable true network centric warfare concepts. This project hosts many of DARPA's most innovative communications and networking systems. Programs funded are: Polarized Rotation Modulation (PZRM) Communications, the Connectionless Networking (CN) program, the Next Generation (XG) program, the Advanced Speech Encoding (ASE) program, the Symbiotic Communications (SYCO) program, the Optical & RF Combined Link Experiment (ORCLE) program, the Policy Based Network Management program, the Disruption Tolerant Networking (DTN) program, the Network Centric Operations/Battle Command program, the Ultra-Fast Radar (formerly Advanced Antenna Concepts) program, the Fiber-Optical Network for Aerospace Platforms program, the Advanced HF Communications program, the Communications to the Tactical Edge program, the Next Generation Routing and Addressing (formerly Self-Forming Networks) program, the Scalable MNW Architectures for Reconfigurable Transceivers (SMART) program, the DARPA Interference Multiple Access Communications program, the Tactical Combined Fiber-Optical and Free-Space Edge Network (formerly the Terabit Optical Ethernet) program, the SATCOM CX (formerly the Multiple-Input/Multiple-Output (MIMO) Satcom) program, the Wireless Network after Next (WNaN) program and the Networked Bionic Sensors for Language/Speaker Detection program.

**UNCLASSIFIED**

R-1 Line Item No. 51

Page 17 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02	

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Polarized Rotation Modulation (PZRM) Comms (formerly Secure Adaptive Waveforms)	2.013	5.127	4.398	0.000

(U) The goal of the Polarized Rotation Modulation (PZRM) Communications program is to develop new extremely high data rate, point-to-point, wireless communications using the PZRM communications concept, which can be implemented at any wavelength – RF to visible – to exploit the presently unused polarization and rotation dimensions of radiation. The PZRM communications program will investigate the use of polarization, including orthogonal signal spectrum overlay, modulation and the ability for conventional radios to carry all information over the transmitted signal amplitude, phase and frequency. Polarization modulation introduces an additional dimension. A radio with four polarization possibilities would transmit four times the information with all other aspects of the waveform held constant. Use of the antenna as part of the information processing architecture of a radio has not been previously performed. This technology will greatly increase the capability of existing channels without increasing spectrum or modem complexity. The program will be demonstrated as an enhancement to an otherwise state of the art networking system. The Polarization Modulation technology will begin transition to Service applications in FY 2008.

(U) Program Plans:

- Performed simulations to determine bit error rates and the optimum modulation schemes commensurate with the center frequencies and bandwidth permissible.
- Conducted simulations to verify performance predictions and identify component elements.
- Construct a demonstration prototype and undertake laboratory tests to validate PRZM concept.
- Demonstrate at long range under operational conditions.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Connectionless Networking (CN)	5.707	5.580	4.000	2.000

(U) In order to bring data efficiently from high value, but energy limited sensors (such as unattended ground sensors (UGS)), into system architectures like that associated with DARPA’s Network Embedded Systems Technology (NEST), a new fundamental emphasis must be placed on how these kinds of sensor networks communicate. The Connectionless Networking (CN) program will develop technology to allow networks (such as UGS) to send and receive messages without initial link acquisition or previous sharing of routing information. This will improve energy usage per bit of delivered information by as much as 100 to 1,000 times compared to conventional and near-term deployable communications systems. Conventional radio link and network designs expend most of the energy on link establishment and maintenance, as well as packet and network overhead. This energy requirement not only limits the lifetime of energy-limited systems, it unnecessarily fills the radio spectrum, limiting available bandwidth, creates unnecessary risks of detection, and increases thermal loads. These impacts are especially severe for communications with proliferated sensors, or remotely operated weapons. Eliminating the requirement to maintain a continuous network link would enable these platforms to provide continuous connectivity without consumption of power, or compromising emanations. The CN program will exploit existing and available signal processing components, intelligent (processing and memory intensive) routing, and availability of situational information to demonstrate a total energy savings of at least 100 times typical connection oriented network applications. The Connectionless Networking technology is planned for transition to the Special Operations Command, Army, Navy, and Air Force for unattended ground sensors and low duty cycle applications beginning in FY 2009.

(U) Program Plans:

- Translated CN technology design and simulations into actual hardware and software.
- Designed and fabricated prototype CN network node devices, and performed laboratory demonstrations.
- Develop and evaluate candidate approaches for implementation complexity, on-board processor and memory capability/power, overhead, scalability and performance.
- Design and fabricate prototype Connectionless Networking node devices with hardware and form factor suitable for military applications.
- Conduct 30 node field demonstrations using CN devices in a form factor suitable for transition.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Next Generation (XG)	10.916	1.869	5.000	5.000

(U) The Next Generation (XG) program goals are to develop both the enabling technologies and system concepts to provide dramatic improvements in assured military communications in support of a full range of worldwide deployments through dynamic spectrum access. U.S. Forces face unique spectrum access issues in each country in which they operate due to competing civilian or government users of national spectrum. These constraints must be reflected in all force planning and may preclude operation of critical systems. Coalition and allied operations are even more complex to manage, and may severely limit the U.S. ability to fully exploit its superiority and investment in information technology. The XG program approach is to develop the theoretical underpinnings for dynamic access to the spectrum, the technologies and subsystems that enable dynamic access, and the system prototypes to demonstrate applicability to legacy and future DoD radio frequency emitters. The program is investigating methods to leverage the technology base in microelectronics with new waveform and medium access and control protocol technologies to construct an integrated system. The program goals are to develop, integrate, and evaluate the technology to enable equipment to automatically select spectrum and operating modes to both minimize disruption of existing users, and to ensure operation of U.S. systems. The result of the XG program will be to develop and demonstrate a set of standard dynamic spectrum adaptation technologies for legacy and future emitter systems for joint service utility. The XG Communications technology is planned to transition to the Army for implementation in a range of current and future communication systems including the Joint Tactical Radio Systems clusters in FY 2009.

(U) Program Plans:

- Developed initial set of hardware prototypes and undertook initial field experimentation.
- Developed and evaluated candidate approaches for implementation complexity, on-board processor and memory capability/power, overhead, scalability and performance.
- Developed final set of hardware prototypes to evaluate and demonstrate system capabilities in an operational exercise.
- Demonstrated spectrum agility performance of prototypes in field experiments.
- Demonstrated spectrum effectiveness and operational characteristics.
- Develop and demonstrate large-scale network organization and adaptation.
- Conduct medium and large-scale military scenario demonstrations.

**UNCLASSIFIED**

R-1 Line Item No. 51

Page 20 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Speech Encoding (ASE)	6.699	5.383	4.992	4.257

(U) The Advanced Speech Encoding (ASE) program will achieve an order of magnitude reduction of voice communication bit rates in noisy military environments over current state-of-the-art voice encoders (VOCODER). Such a reduction will significantly decrease the probability of detection of transmitted signals and will also decrease the required transmit energy, thereby increasing battery lifetime. The program will pursue two novel approaches toward achieving its goal. One approach builds upon multiple noise-immune sensors that have been combined with traditional coding algorithms to achieve significant improvements in intelligibility and quality in harsh noisy environments at 2,400 bits per second (bps). This approach will be extended to nontraditional ultra-low-bit-rate coding algorithms in order to achieve 300 bps coding capability in harsh military environments. Alternative approaches will also be explored, such as the communication without acoustic information achieved by extracting laryngeal and sublingual muscle signals that are produced when a person generates sub vocal speech. This approach will yield a revolutionary capability in situations where stealth is of the utmost importance, or in situations where acoustic signals cannot be used, such as under water. The Advanced Speech Encoding technology is planned for transition to the Communications and Electronics Command of the U.S. Army after a prototype demonstration scheduled for FY 2009.

(U) Program Plans:

- Demonstrated a voice communication system (sensors plus coder) operating at 1,000 bps that is at least as good as today's DoD standard in harsh military noisy environments.
- Demonstrate a 300 bps VOCODER with intelligibility, quality and aural speaker recognition in harsh military noisy environments that is at least as good as today's DoD standard.
- Develop a prototype communication system and demonstrate the capability for ultra-low-rate coding in a field demonstration.
- Develop techniques to capture and enhance sub vocal signals to enable stealth communication among the warfighter teams.
- Explore the nature of sub vocalic signals (physiological source, speaker dependence, and robustness) and the information content of the signals.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Symbiotic Communications (SYCO)	8.738	2.375	0.000	0.000

(U) The Symbiotic Communications (SYCO) program is developing an airborne passive radar system to enable precision targeting and battlefield situational awareness. SYCO will generate high resolution Synthetic Aperture Radar (SAR) imagery. This system will operate passively and be effective in clear and adverse weather. SYCO has demonstrated a proof-of-concept through ground-based and airborne flight tests. Additionally, a design for a real-time prototype, as well as automated algorithms to enable real-time processing have been developed and tested. To complete this project, the prototype will be developed and packaged to be form/fit/function compatible for transition. The SYCO technology is planned for transition for Service applications in FY 2008.

- (U) Program Plans:
- Demonstrated ground based RADAR operation with real sources.
  - Demonstrated airborne RADAR operation with real sources.
  - Completed end-to-end system design.
  - Develop real-time airborne demonstrator system.
  - Demonstrate high resolution SAR at national imagery interpretability rating scale level 4.
  - Participate in limited user testing.

	FY 2006	FY 2007	FY 2008	FY 2009
Optical & RF Combined Link Experiment (ORCLE)	21.041	14.597	7.560	10.000

(U) The Optical & RF Combined Link Experiment (ORCLE) seeks to develop combined radio frequency (RF) and free space optical (FSO) communications as well as networking technologies that exploit the benefits of complementary path diversity. This effort will demonstrate improved battlespace communications using a hybrid RF and FSO link in air-to-air-to-ground environments. The central challenge is to enable optical communications bandwidth without giving up RF reliability and “all-weather” performance. ORCLE will develop RF and FSO

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

propagation channel analysis, coding techniques and modeling to include weather, atmospheric and aero-optics to provide the joint force commander assured high-data rate communications. The technical objective is to prototype and flight demonstrate hybrid FSO/RF air-to-air-to-ground links that combine the best attributes of both technologies and simulate hybrid network performance. The ORCLE technology is planned for transition to the Air Force in FY 2009.

(U) Program Plans:

- Perform range and flight demonstrations of air-to-air-to-ground hybrid FSO/RF links with high availability and gigabit data flows.
- Investigate the optical channel obscuration mitigation using ultra short pulse lasers and partially coherent beams.
- Execute common/combined FSO/RF apertures that enable transition to operational platforms as replacements rather than addition to current systems while maintaining or improving current capabilities.

	FY 2006	FY 2007	FY 2008	FY 2009
Policy Based Network Management (PBNM)	2.599	0.000	0.000	0.000

(U) Drawing upon lessons learned from the Airborne Communications Node/Adaptive Joint C<sup>4</sup>ISR Node (ACN/AJCN) program and previous DARPA programs in mobile ad-hoc networking, the Policy Based Network Management (PBNM) program has enabled reliable and understandable control of non-homogeneous ad-hoc networks and other communications systems that must interact to support the commander's mission objectives. This effort created a system control methodology allowing intuitive control over complex communications systems while still preserving the flexibility of the emerging ad-hoc networks. In addition to creating a method for an operator to understand the state of the network, PBNM allows the network to implement the commander's intent for the operation by dynamically changing function and allocation throughout the duration of a mission. PBNM controls traffic at the application level by making the system aware of what is currently possible, what is currently allowed, and how communications are expected to change over the duration of a mission.

(U) Program Plans:

- Demonstrated, using wireless networked communications, the ability to control information traffic to satisfy commander's intent and mission needs.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Disruption Tolerant Networking (DTN)	6.633	8.425	8.205	6.100

(U) The Disruption Tolerant Networking (DTN) program is developing network protocols and interfaces to existing delivery mechanisms (“convergence layers”) that provide high reliability information delivery using communications media that are not available at all times, such as low earth satellites, UAV over-flights, orbital mechanics, etc. The program is developing a single model for bundling information and ensuring its delivery, through a series of episodic communications links, from generator to user. Mechanisms and protocols that reduce bandwidth consumption, reduce latency, and improve reliability of information delivered to tactical deployments will be explored. The program is also exploring a new security model which protects information held in portable devices. To maximize the applicability and commercial viability of these protocols, and develop the basic software in an open source mode, the military, commercial and Internet communities have been engaged. These protocols will be implemented in a typical military system to verify both the performance of the protocol and to validate the utility. The Disruption Tolerant Networking technology is planned for transition to the Army and Marine Corps in FY 2009.

(U) Program Plans:

- Demonstrated that information organized into bundles can be delivered across intermittent networks.
- Investigated policy cognitive operation by moving intelligence into networks to make the best choices on delivery.
- Commence research to show “fuzzy scheduling” can make network routing decisions in the presence of uncertainty about available or optimal paths.
- Enable networks to deliver traffic without the end-to-end address and routing information using deferred, hierarchical address binding techniques.
- Develop mechanisms to allow code-base-independent environmentally-aware selection of routing algorithms.
- Demonstrate trusted delivery of bundles across networks in which access to a public key infrastructure is not reliable.
- Demonstrate distributed in-network cache and indexing services.
- Demonstrate information binding on demand from a network cache.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007		
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02		

	FY 2006	FY 2007	FY 2008	FY 2009
Network Centric Operations/Battle Command (Integrated Battle Command)	9.054	11.926	6.229	3.000

(U) The DoD is transforming to a more network centric focus for military operations. Network centrality, among other benefits, facilitates the sharing of situation information and access to resources. Shared situation awareness enables collaboration and self synchronization at all operational levels thereby greatly increasing mission effectiveness. Military campaigns in the future will not necessarily be focused solely on major military operations. These campaigns will involve attempts at conflict avoidance, and if this fails, possibly major combat operations with periods of various security, stability, reconstruction, transformation and transition operations. Future campaigns will be characterized by an increased demand for the commander to employ the most appropriate actions (diplomatic, information operations, military, economic, etc.) against the adversary's various political, military (air, land and sea; regular or irregular), economic, social, information distribution, infrastructure, etc. systems. Commanders in the future will use network centrality to access a larger base of knowledge sources and a greater range of resources and actions. Concurrently, the commander will be challenged to exploit these capabilities to achieve a mixture of appropriate effects.

(U) Until recently, the primary technological emphasis for network centric operations has been on improving command, control, communications and computing, intelligence, surveillance and reconnaissance (C<sup>4</sup>ISR) systems to enable better sensor-decider-shooter linkages. While appropriate, there must also be more emphasis on technologies to assist commanders in understanding the complex operational environment, developing and managing intervention campaigns using an effects based approach to operations that employ all options available to the commander, and synchronizing combat operations, security, stability, reconstruction, transformation and transition operations over the entire time of the campaign.

(U) Initial technologies developed in the program are planned to transition to the Army Network Enabled Battle Command program and to the U.S. Joint Forces Command as an initial capability in FY 2006, with more comprehensive capabilities transitioning incrementally through FY 2009.

(U) Program Plans:

- Developed and demonstrated technologies for integrating modeling and visualization techniques into action/effects exploration and campaign planning with an emphasis on modeling an adversarial coalition's various political, social, economic, information dissemination, service infrastructure, etc. systems as well as its military or insurgent capabilities.

**UNCLASSIFIED**

R-1 Line Item No. 51

Page 25 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

- Develop and demonstrate technologies to support humans in authoring courses of action, development and campaign planning; decompose objectives, to effects, to nodes, to actions; capture and model interdependencies between assumptions, activities and intended objectives, and between intended and unintended effects; and assist the human in synchronizing objectives and activities.

	FY 2006	FY 2007	FY 2008	FY 2009
Ultra-Fast Radar (formerly Advanced Antenna Concepts)	4.769	7.345	3.530	1.000

(U) The Ultra-Fast Radar effort will entail the design, construction, and demonstration of an X-band noise correlating radar with a retro-directive antenna. This effort will research and develop a new type of radar sensor based on the correlations of the Gaussian noise received by an antenna array from a small object located in the far field of the antennas and the retro-directive re-radiation of the correlated noise. The combining and tailoring of noise correlating interferometry and retro-directive antenna arrays into retro-directive noise-correlating (RNC) radar will allow the radar to operate in omni-directional search mode. The result of this project will be a new type of search-mode radar having promising performance in terms of short acquisition time and low probability-of-intercept. The Ultra Fast Radar technology is planned for transition to the Army in FY 2009.

(U) Program Plans:

- Modeled, simulated, and demonstrated detection of fluctuating and multiple targets.
- Conducted X-band radar free space test using early prototype bench equipment.
- Develop an X-band noise correlating radar with a retro-directive antenna to show an approximately 5-times reduction in acquisition time compared to traditional electronically-steered search-mode radar, and an even greater reduction in comparison to mechanically scanned radar.
- Design and demonstrate ultra-fast radar using retro-directive antenna arrays that will show a significant reduction in probability-of-intercept compared to traditional search radars based on coherent transmitters.
- Determine if the concept offers significantly reduced cost and greater simplicity to radar development and antenna designs than current systems.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Fiber-Optical Network for Aerospace Platforms	4.000	5.125	5.000	5.000

(U) The Fiber-Optical Network for Aerospace Platforms program will facilitate building or upgrading military aircraft and other aerospace platforms with a fiber-optical networking infrastructure with many capabilities that are well beyond those of currently used copper-based technology. Originally, the program focused on specific technologies for application on the Navy’s EA-6B Prowler aircraft, however, the program has been broadened to focus on technologies that will provide advanced capabilities to a multitude of military aircraft, shipboard and aerospace platforms. These new capabilities include: scalability in bandwidth and number of connected devices; immunity to electromagnetic interference (EMI) and cable cross-talk; reduced cable and overall system weight and volume; increased reliability without an associated weight or volume penalty; ease of integration and future upgradeability; and the ability to carry mixed analog and digital signal formats. This will be accomplished by taking full advantage of fiber-optical wavelength-division-multiplexing (WDM) technology and leveraging optoelectronic and photonic integration techniques developed in DARPA photonics components program. To reduce size, weight and power requirements and to increase the reliability and the flexibility of interconnecting arbitrarily placed client devices with various signal formats, use will be made of passive, transparent, wavelength-routing technology at the core of the network, and tunable optical transmitters and receivers (transceivers) to inter-connect the client devices at the edge of the network. The technologies developed under this program are planned for transition to the Services in FY 2010.

(U) Program Plans:

- Compile an extended superset of the requirements for a network to be deployed in various target aerospace platforms.
- Create a suitable architecture for a mostly passive, wavelength-division-multiplexing (WDM) fiber-optical network with high connectivity for increased reliability.
- Develop a wavelength plan for interconnecting arbitrarily placed client devices using tunable optical transceivers.
- Develop a protocol for rapid restoration from multiple failures through protection switching or by re-tuning the optical transceivers.
- Conduct an analysis to estimate the resulting network reliability and survivability under various failure scenarios.
- Demonstrate the ability to interconnect client devices with a wide range of analog and digital signal formats.
- Demonstrate the ability to integrate the appropriate combinations of optical devices and components to reduce weight and volume.
- Build and flight-test a network test bed that is representative of a network suitable for one or more target aerospace platforms.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced HF Communications	1.842	3.300	4.000	3.000

(U) The goal of the Advanced HF Communications program is to provide always-available, high-rate communications at long ranges for Special Operations Force (SOF) teams using miniaturized equipment. Currently SOF teams rely on satellite communications (Satcom) for long range connectivity. However, Satcom requires line of site access, and channel availability. The Advanced HF Communications will develop antenna and radio technology to provide high-rate communications at long ranges using ground wave and near vertical incidence skywave (NVIS) propagation. A fundamental challenge is reducing the size, weight and power (SWaP) requirements for SOF applicability. Novel miniature HF antenna technologies and channel adaptive radio technologies will be developed and demonstrated in man portable form factors. The technologies developed under this program are planned for transition to Special Forces in FY 2010.

(U) Program Plans:

- Investigate novel antenna designs for miniature form factor and high efficiency.
- Perform propagation experiments to determine atmospheric effects on communications using both ground wave and NVIS electromagnetic propagation modalities.
- Develop improved statistical models of atmospheric effects on communications to implement effective equalization techniques using state of the art digital signal processing components and algorithms.
- Develop a dual mode transceiver prototype in a package that validates the size, weight and power requirements of the SOF user.
- Perform a field demonstration on a prototype transceiver in various environments to validate the concept.

	FY 2006	FY 2007	FY 2008	FY 2009
Communications to the Tactical Edge	2.375	0.000	0.000	0.000

(U) The future DoD communications architecture will provide a multi-tiered capability consisting of: a worldwide, broadband Global Information Grid (GIG); transportable networks like the Army Warfighter Information Network-Tactical (WIN-T); and totally wireless mobile ad hoc tactical networks formed using the next generation Joint Tactical Radio System (JTRS) terminals. This program researched technology to

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

make networks “user-aware” and oriented toward delivering tailored services to each user by dynamically balancing communications supply and demand. An Information Flow Control Network was studied that acts as a dynamic overlay to existing communications networks while simultaneously serving as an underlay to existing service oriented architectures and other middleware.

(U) Program Plans:

- Studied technology to implement a user-transparent service that dynamically monitors the communications supply available and the communications demand desired at each user (or end system) and is aware of the military missions being executed by each user.

	FY 2006	FY 2007	FY 2008	FY 2009
Next Generation Routing and Addressing (formerly Self-Forming Networks)	3.419	3.557	3.750	6.000

(U) The Next Generation Routing and Addressing program seeks to develop networks that use topographically distributed addresses (e.g., geographically or by organizational unit). Current network routing methodologies use IP address numbers that are distributed in no defined pattern or methodology. As a result, current routing systems spend large amounts of time and computing power updating and maintaining tables that ‘point’ to where different IP addresses are located geographically. The self-forming networks will reduce the load on routers as well as greatly simplify router configuration. These networks will be a paradigm shift in that numbered IP addresses will no longer exist, and changes to the Domain Naming Server (DNS) system will allow for services to mobile users to be incorporated. This program is planned for transition to the Services in FY 2011.

(U) Program Plans:

- Develop machine naming schema for data packets that are geographically based and that allow for fine grained control of precedence and improved quality of service capabilities.
- Develop tactical router replacements that work with existing computers/routers and require no new configuration and enable self-forming networks that will result in at least an order-of-magnitude reduction in training, configuration, and installation time.
- Develop changes to DNS functions to accommodate the forwarding services to mobile users.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Scalable MMW Architectures for Reconfigurable Transceivers (SMART)	5.370	8.534	8.200	8.540

(U) This program seeks to exploit recent advances in analog transmit and receive technology with progress in ultra-high speed logic to simultaneously reduce the transceiver phase noise and reduce analog device non-linearities with digital correction techniques. In particular, the current performance of Silicon Germanium and Indium Phosphide bipolar device technology is now fast enough, with cut-off frequencies of > 350 GHz, that error correction technique such as predistortion and feed forward correction can be considered for application to radio frequency (RF) components. The effort will develop new circuit topologies and algorithms along with cross technology integration schemes. This combination will increase the maximum signal data rate (increase the bits/sec/Hz) for DoD RF links. This program will transition through industrial producers of millimeter-wave radar systems for DoD applications.

(U) Program Plans:

- Study fundamental limits to RF communication links and perform system study.
- Define critical technical challenges to increasing link margin by improving component linearity.
- Establish program metrics for optimum RF link demonstration.
- Initiate component development and heterogeneous integration demonstrations.

	FY 2006	FY 2007	FY 2008	FY 2009
DARPA Interference Multiple Access (DIMA) Communications	5.080	8.458	6.398	5.494

(U) The DARPA Interference Multiple Access (DIMA) Communications program will develop a networked radio system that supports voice and data. The goal of this program is a network that is dynamically controllable using techniques such as reconfiguration, optimum resource allocations based on mission priorities, and dynamic policies, as opposed to relatively passive reactions to changes by the commercial infrastructure. This program will initially develop direct sequence spread spectrum (DSSS) communications technologies as a building block to enable robust, mobile, tactical wireless networks, which are the foundation for network centric warfare concepts. The fundamental technical challenges are scalability, covertness, robustness and platform size, weight and power requirements. The DIMA Communications program will

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

develop and demonstrate a DSSS system based on multi-user detection concepts that can operate in an infrastructureless (ad-hoc networked) environment. The technologies developed under this program are planned for transition to the Army and SOCOM in FY 2010.

(U) Program Plans:

- Demonstrate feasibility of concept in a wireless test bed.
- Develop optimized waveform, multi-user detection processing and channel parameter estimation algorithms.
- Demonstrate system performance through a combination of simulation and hardware prototype field demonstrations.

	FY 2006	FY 2007	FY 2008	FY 2009
Tactical Combined Fiber-Optical & Free-Space Edge Network	0.000	3.024	3.000	7.000

(U) Based on technologies developed under the Next Generation Optical Networks program (budgeted in PE 0602303E, Project IT-03), the Tactical Combined Fiber-Optical and Free-Space Edge Network effort (formerly Terabit Optical Ethernet) will make it possible for the U.S. military to create a rapidly deployable, self-healing, tactical wavelength-division-multiplexed (WDM) fiber-optical network, combined with free-space optical and directed radio frequency (RF) networks, that can provide substantial communications capability to command centers deployed in somewhat mature areas of hostility. Key capabilities that will be enabled by this program include: (1) the elimination of power needs in the core of the network through the design and fabrication of passive wavelength-routing nodes that will allow the switching functions to be done via tunable optical transmitters and receivers (transceivers) at the edge of the network; (2) enhanced network survivability through a suitable highly connected network topology leveraging a fast-restoration protocol capable of rapid recovery from multiple network node and link failures; and (3) extended geographical coverage of the network to hundreds of kilometers, without requiring additional power at the core. In addition, protocols will be developed to enable the connection of this network to tactical wireless networks as well as to existing fixed networks allowing the efficient transmission of a combination of internet protocol (IP), digital video streams as well as analog and digital radar, electronic warfare (EW) and RF signals. The program will also include the development of techniques to realize ruggedized network nodes and interconnecting fiber cables, which are strung along the ground, buried in the ground and/or in riverbeds or other waterways. This program is expected to transition to the U.S. Army and U.S. Marine Corps in FY 2010.

(U) Program Plans:

- Characterize and model the network elements of a combined fiber/free-space optical network.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02	

- Create a suitable architecture for a passive, WDM fiber-optical and free-space network with high connectivity for increased reliability.
- Develop a set of passive, wavelength-routing nodes that can enable the realization of this architecture.
- Develop a wavelength plan for interconnecting client devices with tunable optical transceivers placed at the edge of the network.
- Develop a protocol for rapid restoration from multiple network node and link failures through re-tuning the optical transceivers.
- Conduct an analysis to estimate the resulting network reliability and survivability under various failure scenarios.
- Demonstrate the ability to interconnect client devices with a wide range of analog and digital signal formats and protocols.
- Devise appropriate protocols to enable the integration of the network with existing networks and tactical wireless networks.
- Develop techniques to realize ruggedized network nodes and fiber cables.
- Build and test a network testbed that is representative of tactical networks and environments.
- Investigate innovative methods and technologies for deploying, connecting and maintaining combined fiber-optical and free-space optical and RF networks.

	FY 2006	FY 2007	FY 2008	FY 2009
SATCOM CX (formerly Multiple-Input / Multiple-Output (MIMO) Satcom)	0.000	2.950	3.861	3.425

(U) The SATCOM CX program will develop a proof of concept system that will enable multiple users' access to 100 kilobits per second (kbps) satcom channels using the existing C-band satellite architecture. This new capability becomes possible, in part, by moving away from the existing paradigm regarding usage of these satellites. This new SATCOM CX paradigm envisions satellites as merely a node or relay for a single user. In communications terminology, the satellite is part of a single-input/single-output (SISO) channel. Instead, this program will consider the multiple satellites simultaneously. Using this approach, a multitude of co-channel users sends signals that illuminate a multitude of satellites. Powerful processing algorithms then isolate the individual communication links. Using the constellation in this manner provides signal gain and interference rejection.

(U) The most important advantage for military missions is the ability to use the existing C-band uplink infrastructure with antenna aperture areas several orders of magnitude smaller than are currently needed. The large size of current C-band ground station antennas is driven by the need to limit adjacent satellite interference rather than the need for additional link margin. Operation with drastically reduced apertures is possible

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

if the requirement to avoid illuminating an adjacent satellite is removed. By relaxing beam size requirements, the ground terminal footprint can be reduced. Other satellite constellations with reduced coverage offer greater power and, hence, more capacity.

(U) The increased complexity of the SATCOM CX communication link demands dynamic and adaptive network protocols to ensure optimal performance is achieved. The technologies developed under this program will transition to the Services' expeditionary forces in FY 2010.

- (U) Program Plans:
- Develop the system design requirements.
  - Develop the system components.
  - Integrate the components and demonstrate the communications capability.
  - Demonstrate the fundamental capability enhancement using processed data.

	FY 2006	FY 2007	FY 2008	FY 2009
Wireless Network after Next (WNaN)	0.000	2.700	4.000	8.509

(U) The Wireless Network after Next (WNaN) program goal is to develop and demonstrate technologies and system concepts enabling densely deployed networks in which distributed and adaptive network operations compensate for limitations of the physical layer of the low-cost wireless nodes that comprise these networks. WNaN networks will manage node configurations and the topology of the network to reduce the demands on the physical and link layers of the nodes. The technology created by the WNaN effort will provide reliable and highly-available battlefield communications at low system cost.

(U) The WNaN program will develop a low-cost handheld 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. This program will culminate in a large-scale network demonstration using the multi-channel nodes. WNaN technology is planned for transition to the Army in 2010.

- (U) Program Plans:
- Design, integrate and test handheld, multi-channel wireless nodes that utilize inexpensive RF circuits and narrowband tuning filters.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Command, Control and Communications Systems PE 0603760E, Project CCC-02	

- Develop, integrate and test network technologies/processes that exploit diverse paths and frequencies to support network scalability and network formation of tens of thousands of operational nodes.
- Demonstrate a communication system where the network layer can mitigate shortfalls in the physical layer.
- Demonstrate large scale operation of 500 to 1000 nodes integrated into a highly adaptive, dynamic, self-forming, self-healing WNaN military network.

	FY 2006	FY 2007	FY 2008	FY 2009
Networked Bionic Sensors for Language/Speaker Detection	0.000	0.000	3.000	5.500

(U) The Bionic Sensor program will develop and demonstrate low-power micro-sensor devices and networks for language/speech detection and recognition processing to detect voice activity, including speaker ID recognition in villages known to be insurgent recruitment “hot-spots”. The system will use ultra low power signal conditioning/processing front end processors with language/speaker recognition algorithms for distributed sensor network applications in the battlespace. Networked bionic sensors will be able to make detections within meters from the target providing high SNR (Signal to Noise Ratio, of >10 dB) with sufficient recognition performance in an urban (non-telephonic) environment. This program will provide the ability to discretely monitor buildings, human presence detection/tracking in other sensitive areas, enable force protection, and provide Battle Damage Information. Intelligence, Surveillance, and Reconnaissance (ISR) capabilities can be enhanced with this technology by covertly detecting and tracking high value targets with hand emplaced or air deployed sensor networks. The technology developed is planned for transition to the Marines in 2010.

- (U) Program Plans:
- Develop low-power micro-sensor devices and networks.
  - Recognition of social associations.
  - Identify insurgent and terrorist activity.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Land Warfare Technology PE 0603764E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	107.171	44.805	24.711	32.612	56.890	57.097	57.097	57.097
Rapid Strike Force Technology LNW-01	16.371	36.755	24.711	32.612	56.890	57.097	57.097	57.097
Future Combat Systems LNW-03	90.800	8.050	0.000	0.000	0.000	0.000	0.000	0.000

**(U) Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior.

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces, particularly in urban areas where both combatants and civilians are present. This project is developing technologies that serve as force multipliers, enabling safe and effective operations in hostile environments. Revival of this project stems from the need to support the development of effective and adaptive weaponry, both lethal and non-lethal, for a variety of target suppression effects. Other technologies to be explored will include tele-operated systems, novel targeting and firing techniques, and advanced situational awareness and response systems.

(U) The U.S. Army's Future Combat Systems (FCS) is envisioned to be a System of Systems (SoS), which will provide capabilities that strike an optimum balance between critical performance factors (e.g., operational and tactical mobility, lethality, survivability, and sustainability) and strategic responsiveness. The FCS program embraces an evolutionary acquisition, spiral development process. This Joint DARPA/Army activity supports the FCS spiral process through the development of critical technology improvements for FCS platform variants and the Network. The resulting network-centric SoS will continue to provide the Unit of Action overwhelming lethality, strategic deployability, self-sustainment, and high survivability over other conventional ground forces.

**UNCLASSIFIED**

R-1 Line Item No. 52

Page 1 of 20

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E	

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<table border="0"> <tr> <td></td> <td align="right"><b><u>FY 2006</u></b></td> <td align="right"><b><u>FY 2007</u></b></td> <td align="right"><b><u>FY 2008</u></b></td> <td align="right"><b><u>FY 2009</u></b></td> </tr> <tr> <td>Previous President's Budget</td> <td align="right">125.384</td> <td align="right">48.975</td> <td align="right">51.480</td> <td align="right">71.092</td> </tr> <tr> <td>Current Budget</td> <td align="right">107.171</td> <td align="right">44.805</td> <td align="right">24.711</td> <td align="right">32.612</td> </tr> <tr> <td>Total Adjustments</td> <td align="right">-18.213</td> <td align="right">-4.170</td> <td align="right">-26.769</td> <td align="right">-38.480</td> </tr> <tr> <td> </td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>Congressional program reductions</td> <td align="right">-15.000</td> <td align="right">-4.170</td> <td></td> <td></td> </tr> <tr> <td>Congressional increases</td> <td align="right">0.000</td> <td></td> <td></td> <td></td> </tr> <tr> <td>Reprogrammings</td> <td align="right">0.000</td> <td></td> <td></td> <td></td> </tr> <tr> <td>SBIR/STTR transfer</td> <td align="right">-3.213</td> <td></td> <td></td> <td></td> </tr> </table>		<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>	Previous President's Budget	125.384	48.975	51.480	71.092	Current Budget	107.171	44.805	24.711	32.612	Total Adjustments	-18.213	-4.170	-26.769	-38.480	 					Congressional program reductions	-15.000	-4.170			Congressional increases	0.000				Reprogrammings	0.000				SBIR/STTR transfer	-3.213			
	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>																																										
Previous President's Budget	125.384	48.975	51.480	71.092																																										
Current Budget	107.171	44.805	24.711	32.612																																										
Total Adjustments	-18.213	-4.170	-26.769	-38.480																																										
Congressional program reductions	-15.000	-4.170																																												
Congressional increases	0.000																																													
Reprogrammings	0.000																																													
SBIR/STTR transfer	-3.213																																													

(U) **Change Summary Explanation:**

FY 2006 FY 2007 FY 2008/2009	The decrease reflects the SBIR/STTR transfer and the Section 8040 rescission. The decrease reflects congressional cuts to HYFORM and FCS Supporting Technologies and a decrease for Section 8106 Economic Assumptions. The decrease reflects re-prioritization and completion of Urban Warfare efforts in Project LNW-01, Rapid Strike Force Technology and completion of the Future Combat Systems project.
------------------------------------	--

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							DATE February 2007	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01				
COST (In Millions)	FY 2006	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013
Rapid Strike Force Technology LNW-01	16.371	36.755	24.711	32.612	56.890	57.097	57.097	57.097

**(U) Mission Description:**

(U) The emerging U.S. vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient land forces, particularly in urban areas where both combatants and civilians are present. This project is developing technologies that serve as force multipliers, enabling safe and effective operations in hostile environments. Revival of this project stems from the need to support the development of effective and adaptive weaponry, both lethal and non-lethal, for a variety of target suppression effects. Other technologies to be explored will include teleoperated systems, novel targeting and firing techniques, and advanced situational awareness and response systems.

**(U) Program Accomplishments/Planned Programs:**

	FY 2006	FY 2007	FY 2008	FY 2009
Multi-Modal Missile (M3)	3.000	9.500	7.000	6.500

(U) The Multi Modal Missile (M3) program will explore the development of an integrated, man-portable weapon system capable of performing surface-to-surface, anti-armor, and surface-to-air anti-aircraft missions with an emphasis on extreme precision. The program will focus on delivering precision targeting accuracy to 1) enable light-weight munitions and thus deeper magazine and/or longer engagement ranges, 2) tailor categories of kill through subsystem targeting, and 3) provide lethal effects against targets otherwise beyond the reach of man-portable weapons. The objective M3 capability will integrate a variety of existing weapons-systems functions and provide the dismounted soldier with a compact system to engage vehicles, rotorcraft, and close air support aircraft. The effort will also explore additional mission concepts to include anti-personnel and breaching applications, beyond-line-of-sight functionality, air-to-ground capability, and ground vehicle mounting options. Critical characteristics of this weapon system concept include light weight, simple operation, and affordability. Technologies under consideration will include advanced imaging seekers and/or operator terminal guidance; low-cost, high-performance, solid-rocket engines; sensor-based fusing;

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Land Warfare Technology PE 0603764E, Project LNW-01	

and novel warhead concepts to support a wide range of engagement geometries with desired lethality effects against a range of targets. This program is planned to transition to the U.S. Army.

- (U) Program Plans:
- Perform initial system design analyses and trade off studies.
  - Initiate critical technology, maturation efforts for seeker, propulsion, guidance and warhead.
  - Develop, analyze and assess initial multi-modal missile system preliminary designs.

	FY 2006	FY 2007	FY 2008	FY 2009
Non-Lethal Alternatives for Urban Operations	1.500	5.500	3.211	3.500

(U) The Non-Lethal Alternatives for Urban Operations effort will explore system concepts and enabling technologies for non-lethal weapons in challenging urban and semi-urban environments. This effort will assess effects, targeting systems, delivery systems, and countermeasures, and will develop integrated less-lethal system options for application to urban warfighting. Effects to be investigated will include less-lethal projectiles, malodorants, entanglers, and marking agents. The effort will consider direct and indirect fire systems to counter personnel and to provide area effects against vehicles, crowds and groups of combatants. Operating scenarios to be explored will include force protection for fixed sites, force protection for mobile forces, situational control (including traction control), individual soldier weapons, border protection, and protection of extended infrastructure. The effort will pay particular attention to technologies that support application on autonomous and teleoperated unmanned ground robotic vehicles in urban environments at a sustained operational tempo. Transition organizations will be the United States Air Force and the National Reconnaissance Office, Special Operations Command, the Army Corp of Engineers' Engineering Research and Development Center, and others may be identified as efforts and systems are developed.

- (U) Program Plans:
- Perform initial concept development and effects assessments.
  - Develop initial urban less-than-lethal system designs.
  - Conduct less-than-lethal technology maturation efforts to address and reduce system risk.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01	

- Develop non-lethal, asymmetric systems that deny vehicle and pedestrian traction.

	FY 2006	FY 2007	FY 2008	FY 2009
Tactical Urban Operations (TURBO) program	2.469	3.425	0.000	0.000

(U) The Tactical Urban Operations (TURBO) program sought to provide dismounts with integrated information from low-level airborne assets, such as the Micro Air Vehicle (MAV) or the Organic Air Vehicle (OAV), local intelligence sources, and responsive and improved fires / effects capable of acting on this information. Technologies explored included: aggregation of information from multiple MAVs and OAVs with other sources into an easy-to-use interface; improved techniques for detecting dismounted targets and distinguishing friend from foe; and improved methods for displaying information to dismounts and allowing them to direct operations without impeding their mission.

(U) Program Plans:

- Defined system architecture and constraints based on MAV ACTD experience.

	FY 2006	FY 2007	FY 2008	FY 2009
PEO-Soldier/Exoskeleton Transition	9.402	7.000	0.000	0.000

(U) The PEO-Soldier Exoskeleton Transition program will employ novel mechanisms, information systems, and power management hardware and software to ultimately produce a wearable machine that will serve as an intuitively operated load carriage system for individuals. The goal of the program is to enable an individual soldier to lift and carry 150 pounds while feeling only a small part of the load, work for long periods of time, and to travel in difficult conditions. This ability for a single soldier to carry heavy loads could be leveraged in applications ranging from moving boxes of ammunition or supplies to enabling the carriage of significantly greater body armor than is presently possible. The Army envisions the Personal Combat Vehicle (PCV) to be a highly armored anthropomorphic vehicle for the individual soldier that can move through rough and urban terrain without difficulty while providing the individual soldier with an unprecedented amount of ballistic protection. This program has transitioned from PE 0602715E, MBT-01, where the underlying smart materials and mechanism development was funded. Transition is planned to the Army in FY 2008.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Land Warfare Technology PE 0603764E, Project LNW-01	

- (U) Program Plans:
- Develop the enabling components and improve the overall system performance of the exoskeleton device against threshold requirements developed in an MOA with the Army (May 2005).

	FY 2006	FY 2007	FY 2008	FY 2009
Concealed Weapons Detection	0.000	6.330	3.500	2.000

(U) The Concealed Weapons Detection program will explore various phenomenologies that will permit concealed weapons detection. Imaging based approaches will be developed utilizing an integrated silicon-based antenna array receiver device to produce whole radar arrays on a single die. Advanced front-end lens/reflector subsystems composed of lightweight, low cost materials must be developed in conjunction with highly sensitive receiver subsystems to extend the standoff range. Alternative sensor approaches are also being explored to provide a multi-mode, multi-sensor solution targeted at improved discrimination. These approaches will incorporate x-ray, THz, and millimeter wave radar to provide multispectral tomographic capability. Specific dielectric properties at various electromagnetic frequencies will also provide measurable fingerprints for material classification. High-performance, real-time image processing algorithms must be executed in real-time and would require the development of a lightweight, low-power processor. This novel concealed weapons detection system could result in a significant reduction in military and civilian casualties. Transition is planned to the operational forces.

- (U) Program Plans:
- Conduct conceptual verification to determine qualitative performance achievable of stand-off imaging detection.
  - Develop candidate conceptual designs meeting objective system performance.
  - Perform laboratory prototype demonstration.
  - Perform brassboard demo of basic penetration performance.
  - Conduct experimental field trials.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Land Warfare Technology PE 0603764E, Project LNW-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Asymmetric Materials for the Urban Battlespace (formerly Urban Obscurants)	0.000	5.000	5.000	5.000

(U) The Asymmetric Materials for the Urban Battlespace program will investigate a novel class of materials that, either by themselves or as part of a system, provide asymmetric capabilities in visible signatures, ballistic/fragment/blast protection, and personnel transport. Friendly forces will be able to see through it and shoot through it, but hostile forces will not. Asymmetric, or “one-way,” materials will support basic unit operations such as raids, cordon and search activities, snap checkpoints, and fire fights. Significant technical obstacles include the design and fabrication of composite or meta-materials with true one-way capabilities, including the ability to “self-heal” if necessary. The materials must be lightweight, respond instantly, and be easy to deploy and retract in confined spaces. Potential transition partners include SOCOM, Army, and Marines.

- (U) Program Plans:
- Explore material architectures that are appropriate to the design concept.
  - Develop material components and architectures and integrate into Asymmetric Materials platform.
  - Perform laboratory and field tests to demonstrate capabilities.

	FY 2006	FY 2007	FY 2008	FY 2009
Deep Speak	0.000	0.000	2.000	3.520

(U) The Deep Speak program is developing new networking, coding, and waveform techniques that enable communications signals to penetrate the surrounding buildings and underground facilities. This will maintain the warfighters’ links to each other and the global network thus magnifying our striking power.

(U) Predictive networking techniques that use current position and velocity information to predict future network topologies will reduce the number of broken links by 90%. Also, by breaking the communications waveform into multiple layers, each encoded at a different quality and energy per bit of information ( $E_b/N_0$ ), it is possible to reduce the sensitivity of the communications system to the unpredictable shadowing and

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01	

fading that occurs in urban environments. For voice transmissions multi-layer waveforms will reduce the transmit energy required by 5 dB, and for video by 7 dB while still ensuring that the transmission is comprehensible. Finally, synthetic speech encoding techniques will vastly reduce the data rate required for transmitting speech, and thus has the potential to increase the signal level at the receiver tenfold. Transition is planned to the Army in FY 2009.

- (U) Program Plans:
- Develop predictive network techniques.
  - Develop multi-layer waveforms for both speech and video transmissions.
  - Develop a very low bit rate synthetic speech encoder that maintains a high level of comprehension.
  - Demonstrate predictive networking, multi-layer waveforms and synthetic speech encoding in typical urban environments.

	FY 2006	FY 2007	FY 2008	FY 2009
Laser Guided Bullet	0.000	0.000	1.500	6.092

(U) The Laser Guided Bullet (LGB) initiative will develop the capability to provide precision long-range, laser-based guidance updates to percussively driven or rocket propelled projectiles with the objective to develop a laser guided bullet. This capability will provide overmatching fire power to ground and vehicle-borne forces and significantly improve first shot effectiveness in engaging distant enemy forces. The development will focus on both the technologies required to enable low-cost, high performance guided projectiles or bullets along with the guidance and targeting systems. This will include new guidance technologies, such as compact MEMS-based thrusters and high-stress tolerant electronics in the guided bullet and new compact targeting systems robust to field operations under a variety of conditions. The technology is planned to be transitioned to the Special Forces and Army Sniper Team.

- (U) Programs Plans:
- Develop and demonstrate initial side-thrust technologies with sufficient authority to move a projectile in flight.
  - Demonstrate closed-loop communications with the projectile in flight.
  - Demonstrate closed-loop control with sufficient timing precision to significantly improve accuracy of projectiles at extended ranges.
  - Demonstrate bistatic guidance operations and incorporate detailed user feedback into system design.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01	

- Develop fieldable prototype for evaluation in the field and transition to ground forces.
- Develop, analyze and assess initial multi-modal missile system preliminary designs.

	FY 2006	FY 2007	FY 2008	FY 2009
Robot Human Teams (RigHT)	0.000	0.000	2.500	6.000

(U) The RigHT (Robot Human Teams) program will develop software that enables warfighters (humans) and robots to work effectively together as teams. The technologies will enable humans to form teams with robots so the combined team is able to leverage the strengths of each to create a unit whose whole is greater than the sum of its parts. The program will design new cognitive algorithms that enable the robots to reason about joint goals or missions, reason about role and task assignment, and engage in distributed collaborative planning with their other teammates. This technology is planned to transition to the Army in the future.

- (U) Program Plans:
- Design distributed collaborative planning algorithms that enable robots to plan with each other and with the warfighters.
  - Create multi-modal interfaces for human-to-robot interaction that support distributed planning and distributed plan execution.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

R-1 Line Item No. 52

Page 9 of 20

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Land Warfare Technology PE 0603764E, Project LNW-03				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Future Combat Systems LNW-03	90.800	8.050	0.000	0.000	0.000	0.000	0.000	0.000

**(U) Mission Description:**

(U) The Army’s Future Combat Systems Brigade Combat Team (FCS BCT) is envisioned to be a System of Systems (SoS), which will provide capabilities that strike an optimum balance between critical performance factors (e.g., operational and tactical mobility, lethality, survivability, and sustainability) and strategic responsiveness. The FCS program embraces an evolutionary acquisition, spiral development process. The program allows for continuous capability upgrades through the introduction of new, enabling technologies throughout the development phase. This Joint DARPA/Army activity supports the FCS spiral process through the development of critical technology improvements for FCS BCT platform variants and the Network. The resulting network-centric SoS will continue to provide the Unit of Action overwhelming lethality, strategic deployability, self-sustainment, and high survivability over other conventional ground forces.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
FCS Supporting Technologies	90.800	8.050	0.000	0.000

(U) DARPA and the Army identified key areas where technology development is needed for potential pre-planned product improvements via the planned FCS BCT Spirals: Class I, II, and III unmanned air vehicles, robotic unmanned ground vehicles, Unit of Action (UA) and above command, control and communications, advanced radar sensor and EW systems, and advanced armament and missile systems.

(U) The Unmanned Ground Combat Vehicle (UGCV) – Perception for Off-Road Robotics (PerceptOR) Integration (UPI) program is integrating and testing autonomous navigation algorithms with the Crusher platform to yield an unmanned ground vehicle (UGV) that operates reliably in obstacle-rich terrain. Two Crusher platforms are being used to port and test methods for perception techniques to optimize autonomous performance. Autonomous mobility is being further enhanced by the use of terrain data for path planning. The program's technologies will

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03	

transfer to the FCS UGV Integrated Product Team activities to include System Development and Demonstration (SDD) efforts and potential early spirals into FCS BCT anticipated to occur in FY 2008.

(U) The Future Combat Systems MultiCell and Dismounted Command and Control program enabled experimentation with advanced command and control information technology. MultiCell emulates the functionality of an entire tactical combined arms force. The program incorporates both unmanned air and ground robotic platforms, headquarters working at the operational level, and human dismounts. MultiCell also provides commanders with recommended interface functions and workload allocations. MultiCell validates the understanding of the dynamics of complex warfighting organizations thus defining commander interface layouts, functions and displays for maximum flexibility and effectiveness. This program recommends capability enhancements supporting technology for the nomination of information sources and supports visualization of current and future operational states. MultiCell enables commanders to successfully prosecute future command and control operations with significantly reduced staff. DARPA established an MOA with the Army for this program in August 2003. The MultiCell Command and Control technology transitioned to the Army at the conclusion of Phase II, completed in FY 2006.

(U) The Maneuver C<sup>3</sup> program will develop robust, assured and potentially high data rate connectivity for the Future Combat Systems Brigade Combat Team (FCS BCT) elements along with a command and control architecture to reduce the number of forward deployed Command and Control (C<sup>2</sup>) operators. The communications component will develop an integrated architecture that provides for a seamless transition from line-of-sight to non-line-of-sight communications. To enable this functionality, development of new secure waveforms, directional antennas and mobile ad hoc networks will be initiated. The C<sup>2</sup> component will directly leverage the Army's investment in the automation of the Battlefield Functional Areas within the Army Battle Command System (ABCS). Because of the multitude of single aspect systems that feed information in ABCS, large amounts of data are made available to the commander, thus requiring a much larger staff of operators and workstation analysts to complete the fusion function of battlefield data into information for the commander to make decisions. Future operations involving FCS technologies and operational capabilities cannot be restricted by a less responsive C<sup>2</sup> architecture and large support staffs.

(U) Two autonomous air vehicle programs were developed to provide reconnaissance and surveillance, and targeting information for small unit FCS direct and indirect fire weapons. A company level vertical take off and landing unmanned air vehicle (VTOL UAV) program developed a vehicle for carrying out airborne surveillance and targeting against ground targets, and a platoon level VTOL UAV was developed for providing small units with an organic reconnaissance and surveillance capability. The company level UAV was developed under the OAV-II program and the platoon level UAV was developed under the Micro Air Vehicle (MAV) program.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Land Warfare Technology PE 0603764E, Project LNW-03	

(U) The Organic Air Vehicle – II program developed lift augmented ducted fan vertical flight vehicles together with associated flight controls, collision avoidance capability, non-line-of-sight communications capability and heavy fuel engine technology. The OAV-II program leveraged several programs in DARPA and the services including advanced communications, sensor developments, the Micro Air Vehicle (MAV) Advanced Concept Technology Demonstration (ACTD), and UAV command and control programs. The dry system weight (no fuel) of the OAV II was 112 lbs. While efforts under the current phase have been successful, the Army has notified OAV contractors that it does not plan to pursue further development of this vehicle.

(U) The MAV ACTD program developed and integrated MAV technologies into militarily useful and affordable backpackable systems suitable for dismounted soldier, Marine, and Special Forces missions. The ACTD focused on the development of lift augmented ducted fan MAVs to accomplish unique military missions, particularly the hover and stare capability in restricted environments. The system provides the small unit with militarily useful real-time combat information of difficult to observe and/or distant areas or objects. The system will also be employable in a variety of war fighting environments (for example: in complex topologies such as mountainous terrain, urban areas, and confined spaces). The MAV ACTD program sought to get DARPA-developed small, Vertical Take – Off and Landing (VTOL) UAVs rapidly into the hands of the users for evaluation and evolution of the technologies; to develop tactics, techniques and procedures; and to provide a residual operational capability to active duty forces. The FCS MAV technology will transfer to the Army during FY 2007, at the conclusion of the ACTD user experimentation.

(U) The FCS laser radar (LADAR) Support (JIGSAW Phase III) program is developing advanced LADAR sensor systems and technologies for foliage penetration. Jigsaw will enable warfighters to accomplish day/night target identification and verification in the most stressing environments at short range (<1km). Environments of interest include targets hidden by foliage and camouflage, and targets in urban settings, such as alleyways. Jigsaw technologies are designed to provide warfighters with reliable combat identification based on a LADAR sensor that will deliver a visual picture of the target scene. The JIGSAW technology is planned for transition to the Army, which is to be completed by FY 2007.

(U) The Foliage Penetration (FOPEN) Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER) initiative supports the Future Combat Systems (FCS) and the U.S. Army Objective Force. The program is developing FOPEN Ground Moving Target Indication (GMTI) radar. This radar promises persistent, long-term detection and tracking of dismounted troops and vehicles moving under foliage and in the open. The technology allows Objective Force commanders to operate with confidence in forested areas. The FORESTER radar will also be able

UNCLASSIFIED

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03	

to detect low-flying aircraft such as helicopters and ultra-lights at ranges out to 75km. FORESTER is a UHF-band FOPEN GMTI radar designed to operate on rotary wing platforms such as the A-160 unmanned helicopter. For GMTI operation, the helicopter flies into the wind to maintain near-zero ground speed. The goal is to detect dismounted troops under foliage at 30 km range under calm to low surface wind speeds. The program employs adaptive processing and innovative radar waveforms to overcome radio frequency interference and electronic countermeasures in hostile electromagnetic environments. The FORESTER technology is planned for transition to the Army at the conclusion of Phase III anticipated to be completed by FY 2008.

(U) The goal of the Affordable Adaptive Conformal ESA Radar (AACER) Program is to develop a high performance radar and communication system for Class IV unmanned helicopters such as the A-160. The Ka-band radar will provide airborne, all-weather, day-night Synthetic Aperture Radar reconnaissance, wide area Ground Moving Target Indication (GMTI) surveillance, dismount detection, and target acquisition and designation for precision fires. It will provide this information directly to the Unit of Action commander via an interleaved data link through the same antenna. The program will develop Electronically Scanned Array (ESA) technology in a small Ka-band antenna. The combination of platform and radar characteristics will provide for persistent surveillance including that in urban areas, with a minimum discernable velocity of 1 mph. The technologies being developed include: (1) affordable radar devices such as phase shifting elements and power amplifiers/combiners which operate at Ka band; (2) miniature receiver/exciter modules generating very broadband waveforms; (3) signal processing algorithms to support multiple functions simultaneously and detect and track dismounts. Use of existing signal and data processing hardware and software will allow an early flight demonstration of the entire system on an A-160 or surrogate aircraft. If successful, this program will provide a vastly improved intelligence and targeting capability for local commanders by providing a dedicated, rapidly taskable asset with surveillance of most of their battlespace, including areas inaccessible or obscured to larger airborne assets. DARPA negotiated an MOA with the Army for this program in August 2005, and the AACER technology is planned for transition to the Program Executive Office – Intelligence Electronic Warfare and Sensors (PEO-IEW&S) at the conclusion of Phase III in FY 2008.

(U) The Electromagnetic (EM) Mortar program will design and demonstrate EM guns (coilgun and railgun) capable of firing modified 120 mm mortar rounds at velocities up to 420 m/s. In addition, this program will also evaluate significant system “trade space issues” for implementation including: 1) ammunition integration and compatibility; 2) vehicle integration concerns; 3) system reliability metrics (barrel life, EM interference); 4) lethality change due to modification; and 5) system supportability metrics. Transition of developed capabilities will be accomplished through the Army FCS BCT program, and is anticipated to occur in FY 2007.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Land Warfare Technology PE 0603764E, Project LNW-03	

(U) The Future Combat Systems Studies, Analysis and Experimentation Program enabled the continued Joint analysis and integration of enabling future land warfare concepts and technologies into the U.S. Army Future Combat System Brigade Combat Team (FCS BCT) program. It enabled the rapid analysis of opportunistic concepts and technologies, and provided support for Joint Force effectiveness modeling of DARPA enabling technologies by the Army Capabilities Integration Center (ARCIC). The program had two initial focus areas: United States Military Academy (USMA) Systems Engineering and Directed Studies.

(U) The objective of the FCS International Cooperation program is to establish and execute Science and Technology Project Agreements with the Republic of Singapore (SN) and the United Kingdom (UK) to identify new S&T initiatives. The program is in collaboration with the U.S. Army. The Singapore Project Agreement initially supported projects to investigate tactical command and control interoperability, explore the use of computer-based technology to mitigate differences between coalition partner planning processes and tools; investigate and assess the utility of various sensor packages on UAV/UGV platforms in dense jungle environments, urbanized terrain and littoral/maritime environments; and determine the applicability of quantum dot technology for developing multi-spectral optic systems. DARPA established an MOA with the Army for this program in April 2004. The agreement with the United Kingdom supports projects to: survey and assess international technologies applicable to the FCS BCT program; compare and assess the coalition effects-based operations planning technologies available from the U.S. and U.K., and conduct an analysis of U.S./U.K. coalition interoperability. The FCS International Cooperation technology program completes in FY 2007, with results being provided to ARCIC and the FCS BCT Program.

(U) The WolfPack program will further develop the initial capability for close approach, networked electronic warfare. The overall effectiveness and efficiency of FCS will be improved by this effort through the development of an advanced, collaborative electronic warfare sensing and attack system. This will provide improved situational awareness in the battlespace for other FCS platforms, thereby improving their survivability in a wide range of scenarios. The improved WolfPack system will be able to detect, locate and jam RF communications as well as providing targeting information to other FCS platforms for kinetic fires or collaborative electronic countermeasures. The WolfPack technology is planned for transition to the Army in FY 2008.

- (U) Program Plans:
- UGCV – PerceptOR Integration (UPI)
    - Integrate vehicle payloads.
    - Commence testing of ported Learning Applied Ground Robots (LAGR) hardware.

UNCLASSIFIED

R-1 Line Item No. 52

Page 15 of 20

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03	

- Conduct operational UPI testing of vehicle, perception and prior data.
- Provides program planning support for the DARPA Urban Challenge.
  
- MultiCell and Dismounted Command and Control
  - Developed prototype command and control interfaces for higher commanders, cell commanders and dismount commanders.
  - Developed supporting operational and systems architectural framework products.
  - Developed a supporting C<sup>4</sup>ISR simulation test-bed to assess the performance of the C<sup>2</sup> prototype.
  
- Maneuver C<sup>3</sup>
  - Validated organic, self-contained approaches versus approaches that “reachback” to other systems for C<sup>2</sup>.
  - Selected wireless communications network architecture(s) for implementation.
  - Demonstrated sub-system components for assured communications in a hostile environment using novel waveforms and beam steering antennas for low probability of detection and anti-jam.
  - Refined Commander’s Support Environment (CSE); expanded CSE knowledge base and collective intelligence module.
  - Continued to refine and expand supporting simulation.
  - Collected and assessed the insights of human-machine interface requirements for training prototypes with the assistance of Army Research Institute.
  - Conducted experiments in support of selected command and control functions for operations with manned/unmanned systems.
  - Completed the development of an initial C<sup>2</sup> experimental demonstrator.
  - Continue experiments of Unit Cell C<sup>2</sup> incorporating limited activities of the dismounted soldier.
  - Extended C<sup>2</sup> architecture to handle inter-unit cell operations, and operations between unit cell and next higher level.
  - Demonstrated an integrated architecture that provides seamless transition from line-of-sight to non-line-of-sight communications via unmanned aerial vehicles and satellite communications.
  - Demonstrate new gateway-based mobile ad hoc networks facilitating radio interoperability among future, current, and legacy military and civilian radios.
  - Perform Technology Maturity Assessment and training with users and National Assessment Group.

**UNCLASSIFIED**

R-1 Line Item No. 52

Page 16 of 20

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Land Warfare Technology PE 0603764E, Project LNW-03	

- Organic Air Vehicle - II
  - Completed Phase II of competitive contracts for system detailed design.
  - Conducted critical design review confirming ability to develop capable air vehicle systems.
  - Completed risk reduction testing on critical vehicle subsystems.
  - Initiated Phase IIIA to build and fly a ~ 112 lb (dry weight) flight vehicle and demonstrate robust flight stability.
  - Demonstrated collision avoidance system performance.
  
- Micro Air Vehicle
  - Demonstrated an enhanced g-MAV (gasoline engine) in military operations in urban terrain exercises and conducted experiments with troops in field trials.
  - Provide Army unit from 25th Infantry Division, 25 MAV systems (50 air Vehicles) as a residual operational capability.
  
- Jigsaw Phase III
  - Developed a form, fit, and function Jigsaw Sensor for integration onto the DP-5X.
  - Developed real-time on-board registration and processing capability.
  - Performed initial flight tests and data collections to demonstrate the utility of the Jigsaw system using a UH-1.
  - Perform flight tests and data collections using a DP-5X UAV.
  - Advance the technologies to a Technical Readiness Level 6.
  
- Foliage Penetration (FOPEN) Reconnaissance, Surveillance, Tracking and Engagement Radar (FORESTER)
  - Demonstrated detection of slowly moving ground targets in foliage by rotorcraft-mounted Ground Moving Target Indication (GMTI) radars through measurements, simulations and analyses.
  - Designed, assessed, and evaluated a brassboard FORESTER hardware system.
  - Design, assess, and evaluate a form-fit-and-function FORESTER hardware system for rotorcraft installation.
  - Design, and fabricate a FORESTER radar and integrate it first on a Black Hawk helicopter and then on an A-160 helicopter.
  - Conduct airborne flight-testing of the FORESTER first on a Black Hawk and then on an A-160 and demonstrate ability to do real-time detection of moving troops under foliage and in the open.

UNCLASSIFIED

R-1 Line Item No. 52

Page 17 of 20

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03	

- Affordable Adaptive Conformal Electronically Steerable Array Radar (AACER)
  - Demonstrated sub-array antennas, with a waveform generator suitable for 3-inch resolution.
  - Fabricated full antenna array (6" x 24") with ~ 50 W average power.
  - Integrate full array and radar system with existing processor and receiver hardware for lab testing.
  - Develop software and demonstrate functionality in A-160 or surrogate flight platform.
  - Train military operators and perform simulated military mission tests and evaluation.
  
- EM Mortar
  - Demonstrated integration compatibility for existing 120mm ammunition.
  - Completed missions and military utility analysis.
  - Demonstrated 3 j/cc capacitor capability in lab.
  - Fabricated coilgun and railgun launchers.
  - Conducted laboratory testing of the launchers with capacitor-based power systems.
  - Complete projectile test round design and fabrication.
  - Assess large-scale manufacturing issues for capacitors and demonstrate operation in a full-size module.
  - Conduct ammunition and weapon system testing.
  
- Studies/Analysis/Experiments
  - Complete systems engineering studies.
  - Complete FCS related directed studies and analysis.
  
- International Cooperation
  - Complete data analysis and force impact of innovative mechanized air assault force concept of operations in command and control jointly developed and evaluated in a wargame environment. Assess Human Factors effects from Coalition operations of U.S. and Singaporean forces.
  - Evaluated the operational performance of DARPA Organic and Micro Air Vehicles and Unmanned Ground Vehicles in complex terrain environments, e.g. jungle and urban.

**UNCLASSIFIED**

R-1 Line Item No. 52

Page 18 of 20

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-03	

- Complete the data analysis of the operational performance of DARPA advanced sensors and advanced sensor exploitation technologies against tactical targets in complex terrain environments, e.g. urban and jungle, performed in Singapore in early FY 2007.
  - Evaluated U.S., U.K. and Singapore Command Post of the Future (CPoF) like technologies for facilitating the exchange of information, investigated concepts for command and control, and explored interoperable architectures demonstrating plug and operate capabilities.
  - Conducted interoperability wargaming.
  - Initiated development of novel quantum dot detector technology for new design concepts for micro-sensors.
  - Surveyed and assessed the applicability of international technologies to the FCS program.
  - Compared and assessed the coalition effects-based operations planning technologies available from the U.S. and U.K.
  - Analyzed U.S./U.K. coalition interoperability of tactical command, control and communications systems.
- WolfPack
- Reduce form factor size of initial WolfPack capability hardware to suit multiple delivery options under the FCS architecture.
  - Refine target set and mission roles to complement existing EW systems with unique WolfPack capabilities.
  - Optimize initial WolfPack power generation and management systems for longer endurance.
  - Demonstrate capability during field experiments.

**(U) Other Program Funding Summary Cost:**

	FY 2006	FY 2007	FY 2008	FY 2009
PE 0603005A Army	25.687	26.490	28.000	29.000

**UNCLASSIFIED**

R-1 Line Item No. 52

Page 19 of 20

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 52  
Page 20 of 20

**370**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	120.486	163.755	151.641	181.971	229.066	222.904	228.322	200.066
Joint Warfare Systems NET-01	38.173	68.084	78.993	89.656	139.657	143.657	143.657	143.657
Maritime Systems NET-02	27.714	34.753	22.770	40.205	33.839	33.839	32.095	3.839
Classified NET-CLS	54.599	60.918	49.878	52.110	55.570	45.408	52.570	52.570

**(U) Mission Description:**

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

(U) The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly expanded capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents utilizing systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often colocated, 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.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Network-Centric Warfare Technology PE 0603766E	

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

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	134.944	174.276	178.032	170.066
Current Budget	120.486	163.755	151.641	181.971
Total Adjustments	-14.458	-10.521	-26.391	11.905
Congressional project reductions	-11.000	-10.521		
Congressional increases	0.000			
Reprogrammings	0.000			
SBIR/STTR transfer	-3.458			

(U) **Change Summary Explanation:**

FY 2006	The decrease reflects the SBIR/STTR transfer and the Section 8040 rescission.
FY 2007	The decrease reflects congressional cuts to Network Command, Network Centric Logistics, FOX, PUCS, and a reduction for Section 8106 Economic Assumptions.
FY 2008	The decrease reflects program repricing in the Joint Warfare Systems project, repricing of various programs funded in the Mobile Undersea Distributed Systems program, and reductions to classified programs.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E	

FY 2009

Increase reflects additional support for the design and development of a large scale shaftless propulsion submarine demonstrator for the Tango Bravo Program.

**UNCLASSIFIED**

R-1 Line Item No. 54

Page 3 of 26

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**  
R-1 Line Item No. 54  
Page 4 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Joint Warfare Systems NET-01	38.173	68.084	78.993	89.656	139.657	143.657	143.657	143.657

**(U) Mission Description:**

(U) The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly expanded capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents 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 colocated, 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, which acquire targets of opportunity, cuing network-based analysis of likely enemy operations and developing warfighter tools, thus maximizing the presence of ground forces in stability and support operational environments.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Network Command	11.646	13.216	13.393	14.000

(U) The Network Command program leverages recent advances in network computing to dramatically improve collaboration among physically separate command posts. The program allows commanders and their staffs to share situation information, develop coordinated battle plans, generate and compare alternate courses of action, and assess likely outcomes, without conventional group briefings. Network Command

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

builds on the paradigm established by the Command Post of the Future program, which demonstrated to commanders, working with voice-over IP and robust graphical collaboration software, a coherent understanding of a situation and operational plan without any face-to-face interactions.

- The Network-Centric Situation Assessment program develops and deploys technologies to assess military situations at levels of interest above individual targets. The program uses all-source data to reconstruct unit organizations, mission relationships, logistics connections, and communications connectivity and analyzes data over time to infer movement, communication, and supply patterns. Within this context, capability analyses are provided and future courses of action are hypothesized. The objective is to understand potential capabilities and intentions of opposing forces. This effort provides greater understanding of opponents' force structures, capabilities, and operational practices, and then enables commanders to sustain effects-based targeting rather than simple attrition strategies. The program provides a context for discovering vulnerabilities in opposing forces and provides cues for intelligence, surveillance, and reconnaissance planning, as it suggests areas of future enemy activity that merit intense scrutiny. Technologies are planned to transition to the U.S. Army Distributed Common Ground Station.
- The Joint Mission Rehearsal program integrates high-fidelity, mainframe-based combat simulations with situation assessment and planning tools. The objective is to allow rehearsal of joint missions, while participants are en route to operations or remain at their home stations. The program uses current situation data to: (1) provide initial conditions for the simulations, and (2) plan data to steer the dynamics of the simulations along the selected courses of action. The technology streams data from the simulations for display, then visualization systems are available to the prospective participants. The visualization permits the warfighter to interact with the simulation in a manner consistent with their anticipated role in the mission being rehearsed. The program delivers the capability to practice and fine-tune mission plans for joint military operations and enables commanders and staff to participate from their current location instead of a training facility, thereby reducing deployment needs while improving mission planning and effectiveness. Technologies are planned to transition to the U.S. Army Simulation, Training & Instrumentation Command.
- The Decision-Directed Design and Adaptive Management program will develop a set of tools to adjust information flows within a Command Post of the Future (CPoF) enterprise to match the evolving needs of its operational users. Tools will be developed to analyze, in real time, command structures for critical functions, relations and information flow. These will continually monitor, adjust and estimate performance of the command structure with respect to process allocation and relations, and information sharing. They will provide real

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

time support to modify the responsibilities, relations, tasks priorities and information sharing to meet a dynamic set of command needs across multiple units, echelons, and organizations.

(U) Program Plans:

- Network-Centric Situation Assessment
  - Identify data fields available to a representative theater commander.
  - Apply advanced link-analysis and pattern-matching technology to tactical data.
  - Evaluate technologies using real-world data.
  
- Joint Mission Rehearsal
  - Enhance existing mission simulations to require “red cell and white cell” participants.
  - Develop tools to rapidly assemble new mission scenarios from existing data sources.
  - Develop techniques to infer data needed by the simulations.
  
- Decision-Directed Design and Adaptive Management
  - Extend and develop emerging computational techniques for analysis and estimation of quality of organizational performance as a function of task assignments and information flows.
  - Develop tools to predict performance based on current organizational structure and expected additional tasks.
  - Design and execute a series of realistic wargame-based experiments to exercise those tools and validate their technical assumptions.
  - Integrate tools into the CPoF infrastructure and transition to the Army.

UNCLASSIFIED

R-1 Line Item No. 54

Page 7 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Precision Urban Combat Systems (PUCS)	5.243	10.665	14.600	17.000

(U) The Precision Urban Combat Systems (PUCS) program is developing and validating advanced sensor, exploitation, networking, and battle management capabilities for joint dismounted forces in urban combat. The program includes detection and tracking of potential enemy targets, discrimination and identification of friendly versus enemy units, sorting of enemy from neutral and non-combatant personnel, coordination of sensing, maneuver, and fires, and continuous assessment of results. PUCS will utilize technologies including: smart networks of distributed imaging and non-imaging sensors; sensors with the capability to detect hidden human targets; improved 3D visualization systems, and multi-spectral discrimination systems that survey the battlefield for weapon activity and detect primary signatures. These capabilities will be developed within the framework of both legacy forces and expected future forces. The program will provide a set of prototype demonstrations of the capabilities in surrogate urban combat environments. Technologies are planned to transition to the U.S. Special Operations Command.

- The Smart Dust Sensor Networks Applied to Urban Area Operations program will provide persistent staring reconnaissance, surveillance, and target acquisition of the three-dimensional urban battlespace using a dense network of ground sensors. The system concept consists of ubiquitous and inconspicuous low-power, small and easily concealed ground sensors distributed throughout the urban landscape. The program includes the development of ultra small sensor nodes for easy deployment and concealment in a crowded urban environment and data fusion algorithms to exploit the abundance of new information provided by a dense urban spatial network. The program will create a self organizing system that will integrate and exploit reliable networks of low-cost, small, and long-lifetime sensor nodes providing the capability for monitoring secured areas (e.g., buildings) and providing situational awareness to warfighters (e.g., checkpoints and sniper fire), and intelligence applications such as wide-area persistent surveillance of roadways and major arteries (e.g., for Improvised Explosive Devices (IED) emplacement), perimeters, and even city wide areas. The program technologies will transition to the Army.
- The Networked Acoustic-Visual Imaging System (NAVIS) (formerly Head Mounted Alerting for Urban Operations) program will develop a networked weapon fire detection system using infrared sensor imagery fused with acoustic sensor information for precise localization of the source of weapon fire. The NAVIS system is a soldier-borne sensor array that moves with the dismounted unit, continually adapting to the dynamic threat situation in urban operations. The system exploits all available infrared and acoustic event data and correlates all

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

observables from a multi-sensor, multi-node, networked array to minimize false alarms and maximize accuracy. The challenge of this initiative is to provide a moving networked sensor array, borne by dismounted warfighters, with near real-time visualization of the fused firing event data for immediate response and accurate pointing.

- The Exploiting Vibrations to Monitor Activities in Buildings program will develop procedures and sensors to characterize activity inside structures based on acoustic/seismic information. The types of information sought include number and location of personnel, foot traffic, operation of building mechanicals (ventilation, cooling, and heating; plumbing; etc.) as an indicator of human activity, operation of other machinery, door openings and closings, and speech. Algorithms that infer internal layout of the building from the pattern and location of these activities will be investigated along with the fusing of the information from other surveillance information gained by other sensing modalities.
- The Total RF Detection and Ranging (TORDAR) program will address radar deficiencies due to discontinuous bandwidth: reduced range coverage, denial in certain geographic regions, interoperability issues, and reduced range resolution. This will involve a system-wide redesign of radar optimized over the full RF spectrum, not individual stove-piped tasks. It will include the integration of sparse bandwidth returns (including passive signals of opportunity), adaptive transmitter and waveform diversity, and agile frequency diverse hardware. It will also use all RF and radar resources more intelligently to fill gaps in knowledge as opposed to re-deriving situational awareness with every new radar processing interval. This capability will facilitate both manned and unmanned airborne Intelligence, Surveillance and Reconnaissance (ISR).
- The Urban Ops Hopper program will develop a semi-autonomous hybrid hopping/articulated wheeled robotic platform that could adapt to the urban environment in real-time and provide both surgical lethality and/or ISR to any point of the urban jungle while remaining lightweight, small and expendable to minimize the burden on the soldier. In general, small robots or unmanned ground vehicles (UGV) are severely limited by obstacle negotiation capability. The demonstrated hopping capability allows small UGVs to overcome obstacles 40-60 times their own size. Hopping will extend robot navigation to six degree-of-freedom situational location and mapping. Hopping mobility can be shown to be 5 times more efficient than hovering for obstacles at heights less than or equal to 10 meters. The proposed hopping robot would be truly multi-functional in that it will negotiate all aspects of the urban battlefield to deliver ISR and/or lethal payloads to non-line-of-sight targets with precision. The articulated wheel design allows the robot to negotiate short range obstacles for precision placement in difficult terrain.

**UNCLASSIFIED**

R-1 Line Item No. 54

Page 9 of 26

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

(U) Program Plans:

- Smart Dust Sensor Networks Applied to Urban Area Operations
  - Develop miniaturized sensors based on Network Embedded Systems Technology (NEST) concept.
  - Develop and demonstrate technologies to separate targets from background.
  - Develop battlefield activity alert logic.
  - Conduct demonstration at a representative MOUT site.
  
- Networked, Acoustic-Visual Imaging Systems (NAVIS)
  - Develop dynamic network sensor processing algorithms.
  - Develop fusion emulator for post processing data analysis.
  - Conduct testing and data collection under controlled motion conditions and various conditions.
  - Develop brassboard processor with sensor and fusion processing algorithms.
  - Conduct live-fire testing under controlled motion conditions in realistic urban conditions.
  - Develop real-time fusion and visualization software.
  - Design and develop a man-wearable NAVIS prototype.
  
- Exploiting Vibrations to Monitor Activities in Building
  - Collect acoustic/seismic data from a set of sample buildings.
  - Develop and demonstrate technologies to separate targets from background and summarize activity.
  - Demonstrate at a representative MOUT site.
  
- Total RF Detection and Ranging (TORDAR)
  - Develop conceptual design and algorithm requirements of spectrum utilization approaches.
  - Demonstrate spectrum utilization approaches with ground based sensing architectures.
  - Develop airborne demonstration.

UNCLASSIFIED

R-1 Line Item No. 54

Page 10 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

- Urban Ops Hopper
  - Demonstrated required hop height and length to meet current urban combat obstacle clearance.
  - Develop 3D ISR obstacle detection, classification, and mapping tools for an unknown environment.
  - Develop precision hopping through restricted pathways to include windows and stair wells.
  - Evaluate technologies in a real-world environment.

	FY 2006	FY 2007	FY 2008	FY 2009
Effects Based Network Targeting	2.723	4.500	5.000	8.000

(U) The Effects Based Network Targeting program is developing technology to identify, determine vulnerabilities, target, and anticipate workarounds in enemy networks. These techniques use all-source information to continuously update models of urban networks. Using the models, operational objectives for urban interventions, expressed in terms of desired and undesired effects will be generated. The technology will then use these objectives to find vulnerabilities in the networks, nominating targets for prosecution to maximize desired effects while minimizing undesired effects. Further, the program will develop techniques for predicting those observables that will rapidly identify an opponent's response when several courses of action are available. In particular, the program will focus on radio frequency networks: identifying transmitters, receivers, and links between them. The program will apply advanced beam forming technologies to provide co-channel interference cancellation for densely deployed cellular telephone or WiFi services in an urban environment. From this understanding of the network topology, courses of action for precision jamming or flooding attacks can be assessed, including determination of effects on downstream components (subscribers to the network). Technologies are planned to transition to the U.S. Strategic Command.

(U) Program Plans:

- Develop tools to: (1) extract relevant information from source data (especially signals, text, and imagery); (2) correlate that information to existing models; (3) update the models while resolving conflicts among sources; and (4) analyze the overall effect of newly discovered changes.
- Conduct measurements of various signals of interest under a set of geometric conditions, which span the range of potential surveillance system employments.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

- Develop and evaluate algorithms for signal geolocation and copy over a range of interference conditions.
- Complete a Preliminary Design Review (PDR) for a demonstration sensor system.
- Develop concepts for operation and identify transition opportunities.
- Design tools to analyze networks, singly and in combination, in order to identify vulnerabilities to predict effects of candidate interdictions.
- Demonstrate selected tools on real-world cases, validating against historical and natural situations.

	FY 2006	FY 2007	FY 2008	FY 2009
Confirmatory Hunter Killer System - CCLR	5.928	6.481	7.000	6.000

(U) The Confirmatory Hunter-Killer System program is developing a low cost expendable loitering weapon/unmanned air vehicle for deployment in urban environments. The program is developing a hand-held, tube-launched, fiber-optic guided, loitering munition suitable for non-line-of-sight (NLOS) target prosecution by individual warfighters in urban environments. It will be an agile NLOS weapon that extends the warfighters' zone of engagement from 200 meters line-of-sight to 2000 meters NLOS. The guided munition will be capable of striking targets from significantly expanded avenues of approach, e.g. over the tops of buildings and around corners, at a distance of up to 10 blocks depending on the specific terrain and building features. A variant capability would include an ultra light designating and ranging system that could be mounted into an organic UAV and remotely piloted by ground crews. This system will develop a highly efficient prototype designating/ranging laser and advanced software needed to integrate into pointing and tracking equipment, and communication and control instrumentation. This program is planned for transition to the Army in 2012.

- (U) Program Plans:
- Conduct concept feasibility through analysis and modeling of the designator laser.
  - Design and build prototype designator laser with electronics board sufficient to drive laser.
  - Develop and demonstrate tracking and communication and control instrumentation.
  - Construct prototype vehicles and conduct field flight tests.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Sensing and Patrolling Enablers Yielding Enhanced Security (SPEYES)	4.633	7.010	10.000	10.000

(U) The Sensing and Patrolling Enablers Yielding Enhanced Security (SPEYES) program provides technologies for Stability and Support Operations (SASO) to enhance the capabilities of our current ground forces in Iraq and Afghanistan. The first program phase evaluates and inserts mature advanced ground-based C3I technologies for three problem areas (Fixed Site Security, Patrolling, and Cordon & Search), seeking to effect a significant force-multiplier improvement through transformational Tactics, Techniques, and Procedures (TTPs). Key Component Technologies include: 1) WASP Micro UAV, 2) Eye Ball R1 Throwable Camera, 3) Leave Behind Intrusion Detection Sensor, 4) SPEYES Handheld PDA Device, and 5) Vehicle Weight Analysis Software and Video/EOD Underbody Sniffers. Later program phases will develop technology to enable mobile HUMINT collection and real-time data analysis to support dismounted soldier patrolling urban areas. The program will include (1) networked mobile devices for collecting HUMINT, communicating new information to a local headquarters, and displaying analysis of the newly collected data; (2) headquarters-level automated real-time analysis of the current state of the observed network to identify gaps in the knowledge base, provide information on the individuals a patrol is interviewing, and generate additional information requests. The technology is planned for transition to the Army and Marine Corps.

(U) Program Plans:

- Develop/procure prototypes of selected SPEYES technologies.
- Plan, conduct, and evaluate appropriate training events with selected Marine and Army deploying units to determine employment CONOPS.
- Following ruggedization of selected prototypes, provide deployable technology for movement to theater.
- Develop new technologies and a system architecture to support real-time HUMINT collection and analysis.
- Develop simulation test bed to evaluate selected network algorithms.
- Design, conduct and analyze field experiments using test bed and National Training Center at Ft. Irwin.
- Evaluate system functions for both individual and staff level functions in culturally specific environments at the National Training Center.

**UNCLASSIFIED**

R-1 Line Item No. 54

Page 13 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Multi Dimensional Mobility Robot (MDMR)	8.000	10.240	5.000	2.000

(U) The MDMR program will investigate concepts using serpentine mobility to achieve new ground robot capabilities for search and rescue applications. The MDMR system will navigate complex urban terrain and provide the operator with real time images of its environment. Examples of the capability include: overcoming obstacles that are a significant fraction of its length, crossing slippery surfaces, ascending poles, and climbing steep slopes. The MDMR platform will be able to support a variety of search missions in hazardous environments such as urban rubble piles. To achieve such a degree of mobility, design concepts must address system challenges such as: on board power management; situational awareness; complex terrain navigation; and system controls. The technology is planned for transition to USSOCOM.

(U) Program Plans:

- Demonstrate serpentine mobility from a base level approach.
- Integrate the robotic system and user interface control.
- Develop and test tele-operation control.
- Perform rigorous testing to characterize system performance and spiral new technology developments into the existing platform.
- Develop and test sensors suitable for integration onto the serpentine platform.
- Transition platform to search and rescue users and demonstrate new capabilities.

	FY 2006	FY 2007	FY 2008	FY 2009
Human-carried Explosive Detection Stand-off System (HEDSS)	0.000	4.000	5.000	7.000

(U) Insurgent and terrorist elements are increasingly relying on human carried explosives because they are nearly impossible to visibly detect. The goal of the Human-carried Explosive Detection Stand-off System (HEDSS) program is to develop a system that can rapidly identify human-carried explosives (HCEs) at a stand-off range between 50 and 150 meters. While alternative technologies exist for HCE detection, they necessitate close-in sensing, are expensive and require extended processing times. Successful development of a HEDSS with detection ranges of

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

50 – 150 m will provide reliable protection for deployed forces from suicide bombers by allowing enough time and space to interdict bombers before they cause maximum damage. The technology is planned for transition to the Army and Marine Corps.

- (U) Program Plans:
- Conduct proof-of-concept experiments and perform system level analysis designed to validate key technical assumptions and identify major system design parameters.
  - Design components and system.
  - Build and integrate system and conduct lab experimentation.
  - Conduct extensive field testing of the system under realistic threat conditions.

	FY 2006	FY 2007	FY 2008	FY 2009
Federated Object-level Exploitation (FOX)	0.000	7.000	11.000	12.656

(U) The Federated Object-level Exploitation (FOX) thrust will provide a new set of geospatial intelligence products, continuously updated and maintained in a form that ensures their consistency across both product elements (digital elevation models, traditional maps, 3D structure models, census summaries, and directories) and spatial nodes (coarse resolution country data for economic analysis to fine resolution building data for platoon-level combat operations). Included programs will combine techniques including model-based image analysis (both object recognizers and change detectors), symbolic correlators (both temporal and spatial), and emerging cognitive methods to identify changes to objects, addresses, names, and functions of natural and man-made structures. These algorithms will be scaled to operate on data streams including full-motion video, lidar, text, and tabular data, in addition to conventional geospatial imagery. Federated algorithm architectures will be explored to achieve scalability through spatial, temporal and ontological partitioning. FOX technologies are planned for transition to the National Geospatial-Intelligence Agency.

- The Auto Metadata Extractions effort will build a system to automatically (with no man-in-the-loop) extract metadata from terabytes of multi-sensor imagery and signals per day. Extracted metadata will include both platform generated information (classical metadata) and algorithmically extracted features and internals. The extracted metadata will be (a) produced in a unified framework, and (b) sufficiently

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

semantically rich to support both semantic information fusion and development of multi-dimensional predictive models. The system will provide all of the fundamental extracted data required for advanced exploitation technology development.

- The Exploitation Language Technology for GeoINT program will build a system to extract and linguistically confirm terms and labels of geographic significance from graphical, textual and audio sources. The program will develop the technology to associate and verify the extracted information against features extracted from imagery. Both extraction and association will be performed against and across multiple languages. A major effort will be made to develop necessary database and query technology to support a wide range of GeoINT specific concepts, e.g., feature classes, complex distance calculations, and boundaries.
- The All Things Repository effort will develop a system capable of ingesting 400 terabytes of multi-sensor all-source imagery, Moving Target Indicator (MTI) and signals per day. The program will build a fully automated metadata and features extraction framework to process all incoming data, and develop the distributed very-large database technologies required to provide both the raw sensor data and extracted features data to a multi-level exploitation user community, both human users and automated agents. Work-flow aware data transformation, data aggregation and data caching technologies will be developed to rapidly provide the user with access to the correct subset of the data rapidly and at appropriate bandwidth.

(U) Program Plans:

- Auto Metadata Extractions
  - Develop a unified processing infrastructure for the generation of metadata from all-source data.
  - Demonstrate a unified semantic representation of metadata generated from all-source data.
  - Demonstrate the collection/conversion of platform generated metadata into the unified representation.
  - Demonstrate generation of metadata from all-source imagery and signals into unified representation.
  - Demonstrate generation of metadata from fusion of prior metadata into unified representation.
- Exploitation Language Technology for GeoINT
  - Demonstrate extraction of geographic terms, (e.g., city names, and their association with geolocations from textual and graphical sources).
  - Develop a multi-lingual ontology of geographic language.

**UNCLASSIFIED**

R-1 Line Item No. 54

Page 16 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

- Demonstration extraction of geographic language from graphical, textual and audio sources.
- Demonstrate multi-lingual queries of geographic language from a large collection of extracted terms.
  
- All Things Repository
  - Demonstrate a multi-source co-registered database over a village sized site.
  - Demonstrate unified access in a single query to multiple spatial and temporal data types.
  - Demonstrate incorporation of automated feature extraction into high volume data flow.
  - Experimentally determine where data volume causes system failures.
  - Demonstrate solutions to very large data volume induced failures.
  - Demonstrate data selection and summarization based on prior work-flows and access.

	FY 2006	FY 2007	FY 2008	FY 2009
Seismic/Acoustic Vibration Imaging (SAVI)	0.000	4.972	6.000	8.000

(U) The Seismic/Acoustic Vibration Imaging program will develop the capability to locate both near-surface tunnels and landmines with active seismic and acoustic sources. These systems will employ well characterized seismic and acoustic sources to stimulate the targets of interest from a remote platform. The interaction of the near surface seismic waves with tunnels and other objects will be observed with a multi-pixel laser interferometer system and used to assess the depth and extent of the targets in the midst of natural and man-made clutter. Similarly, focused acoustic sources will be employed to remotely stimulate plastic or metal antipersonnel and antitank mines. A laser interferometer system will be used to detect the resonant characteristics of the mines to discriminate against natural sources of clutter. The systems developed under this effort will be tested against a wide variety of soil types and environments to support operations under a wide range of conditions. Upon successful development of the initial and objective systems, the capabilities will be transitioned to the Army and Marine ground forces for the development and employment of operational systems starting in FY 2011.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

- (U) Program Plans:
- Develop conceptual system designs meeting objective system performance.
  - Initiate and demonstrate the technologies required for the laser interferometer system, including the sources and sensors, as well as the mobile seismic and directional acoustic sources.
  - Develop and demonstrate a scalable brassboard system for mobile operations.
  - Scale the system to form-factored prototype and verify performance.
  - Transition systems technology to Army and Marines for incorporation into future force structures.

	FY 2006	FY 2007	FY 2008	FY 2009
Quarantine Toxic UAV Payloads	0.000	0.000	2.000	5.000

(U) The Quarantine Toxic UAV Payloads program will develop a system which can safely and effectively sequester (entomb) toxic chemical and biological agent payloads located on hostile force unmanned aerial vehicles. While technology for detection, tracking, and destruction of these platforms exists, the destruction step is problematic since the process can inadvertently disperse the toxic agent over the intended (or other) targets. A means for safely, effectively, and inexpensively sequestering chemical payloads, and transporting these payloads to the ground, is a critical need. This program focuses on the development of a system, which integrates the tracking and detection capabilities with gentle methods of entombment (i.e., quarantine) of the active agent. Such methods include use of rapidly expanding polymer foams or rheology-changing fluids, which form a rugged, impermeable cocoon that effectively isolates the agent (or the entire vehicle) from the environment. Alternative methods, including collecting the agent into a trap, are also possible. Significant technical obstacles include achieving rapid and complete encapsulation (or entrapment), robustness toward countermeasures (including on-board explosives), and the gentle transport of the encapsulated package to the ground. Potential transition targets include SOCOM, Army, and Marines.

- (U) Program Plans:
- Develop strategies and system architecture for entombment of UAV-borne chemical and biological agents.
  - Develop materials and delivery techniques.
  - Perform laboratory and field tests to demonstrate system capabilities.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-01	

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**  
R-1 Line Item No. 54  
Page 20 of 26

**390**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-02				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Maritime Systems NET-02	27.714	34.753	22.770	40.205	33.839	33.839	32.095	3.839

**(U) Mission Description:**

(U) The objective of the Maritime Systems project is to identify, develop and rapidly mature critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Improvements in communications between and among submarines, surface ships and naval aircraft have allowed these forces to operate seamlessly with each other and with other Service's network centric systems. Naval forces will play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea and their versatile ability to provide both rapid strike and project-sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces. This project funds the Mobile Undersea Distributed System (MUDS) program, the Jet Blast Deflector program, the Non-Linear Dynamics for Anti-Submarine Warfare (ASW), and the Tango Bravo technology demonstration program.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Mobile Undersea Distributed Systems (MUDS) Program	13.714	16.753	4.365	4.000

(U) The Mobile Undersea Distributed System (MUDS) program goal is to enhance operations in the littorals to counter asymmetric threats posed by diesel submarines and other forces operating in the littorals, by distributing countering capabilities throughout a complimentary and networked system of sensors and platforms. The network-centric MUDS program includes the Persistent Ocean Surveillance effort, Warfighting in the Littoral effort, the Aluminum Combustor effort, and the River Eye effort.

(U) The Persistent Ocean Surveillance program combined geolocation techniques such as the global positioning system with station keeping and intra-sensor communication technologies to provide long-term station keeping ocean environment sensing buoys. These technologies, when applied with state-of-the-art undersea warfare sensors, have resulted in a floating field of smart sensors capable of observing the undersea

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-02	

environment in an area, including the presence of submarines and other undersea vehicles. A range of technologies have been considered including those that rely on the local environment (such as wind, ocean waves, solar energy, temperature differentials, etc.) for their power, miniature geolocation technologies, and technologies for sensor data storage, transmission, and intra-field communications. Persistent Ocean Surveillance-Station Keeping technology is planned for transition to the Navy.

(U) The Aluminum Combustor program seeks to develop an energy-dense air-independent underwater power source as a potential propulsion system for underwater vehicles. This program will optimize the design for a small combustor and develop the auxiliary power system components needed to control and sustain operations. In addition to the combustor, the aluminum fuel feed subsystem, aluminum-steam separator subsystem; and closed loop control subsystem will be designed, built, and tested and integrated with a turbine in order to successfully demonstrate a power system in a laboratory environment. The Aluminum Combustor technology is anticipated to transition to the Navy.

(U) Early entry maritime forces need maps of morphology, water depths, and currents in complex riverine/estuarine environments for mission planning and execution. This information is critical for route planning, sensor placement, rendezvous determination, vulnerability assessments, and for determining objective assault engagement/disengagement strategies. For uncharted and/or denied areas, present methods are inadequate for obtaining the necessary information. Reliable remote sensing methods do not exist that produce bathymetry and water current data in waters that are sediment laden (bottom is not visible) and/or sheltered (swell and significant wind waves are not likely). The River Eye effort will provide a new capability to predict or assess, in real time, river and estuary conditions to enable special operations mission planning and execution. New techniques will be developed to indirectly determine current speed and direction by remotely sensing advection of scene features. Using advanced modeling techniques, indirectly sensed current data will be used to extract bathymetry data. Forward circulation models will use the bathymetry data to predict future currents and water heights in a mission planning decision support tool. The River Eye effort is anticipated to transition to the Navy and National Geospatial-Intelligence Agency in FY 2010.

(U) Program Plans:

- Mobile Undersea Distributed Systems
  - Continue investigation into novel communications and networking concepts.
  - Explore concepts to reduce platform infrastructure and, ultimately, the cost of future design and production of submarines.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-02	

- Persistent Ocean Surveillance
  - Completed initial 24-hour sea test successfully demonstrating station keeping technologies in two system configurations.
  - Completed design concepts for harvesting energy from the local environment and assessed buoy performance using simulation.
  - Explored the scientific/engineering issues associated with station keeping.
    - Develop energy harvesting technologies and test in laboratory.
    - Integrate energy harvesting technologies with station keeping technologies and demonstrate at sea.
  - Demonstrated feasibility of using nanofluidic technology with moving magnets in linear generated configuration to harvest wave energy.
  - Characterized ferrofluidic material and developed electromagnetic models.
  - Develop a long endurance tactical sized ocean surveillance buoy using exploitable local environmental effects for station keeping.
  - Demonstrate performance at sea.
  - Develop wave energy harvesting applications and test at sea.
  
- Aluminum Combustor
  - Designed and fabricated the low Hp combustor, aluminum fuel feed subsystem, aluminum-steam separator subsystem; and closed loop control subsystem.
  - Commenced integration of the power system in the laboratory.
  - Design a long endurance aluminum fuel feed subsystem.
  
- River Eye
  - Completed analysis on existing circulation models to determine model sensitivity to bathymetry, winds, and fresh water inflow.
  - Revised the Concept of Operations for data collection.
  - Conduct airborne data collections in well-mixed, instrumented estuary.
  - Develop image processing algorithms for extracting circulation currents.
  - Develop inverse model for extracting bathymetry from indirectly sensed currents.
  - Conduct instrumented data collections in a new environment and evaluate performance.
  - Refine and tune algorithms for extracting circulation currents and bathymetry in more complex environments.

**UNCLASSIFIED**

R-1 Line Item No. 54

Page 23 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-02	

- Conduct real time at sea demonstration.

	FY 2006	FY 2007	FY 2008	FY 2009
Jet Blast Deflector	1.000	1.000	1.000	1.000

(U) The Jet Blast Deflector program is an outgrowth of the DARPA structural materials program funded in PE 0602715E. The program will use multifunctional materials to construct a passively cooled jet blast deflection that increases reliability and meets weight reduction requirements for current and future classes of aircraft carriers. A Memorandum of Agreement was signed (January 2004) with the Navy's PEO (Aircraft Carriers) that agreed to, based on a successful sub-scale concept demonstration during FY 2005, full scale demonstration of prototype panel performance at Naval Air Warfare Center, Aircraft Division Lakehurst and a use decision for CVN21.

(U) Program Plans:

- Demonstrate that multifunctional materials can reduce weight by over 50% and will save operations and support costs by 26%.
- Test and validate performance and savings.

	FY 2006	FY 2007	FY 2008	FY 2009
Tango Bravo	10.500	17.000	17.405	35.205

(U) Based on the results of the DARPA/Navy Submarine Design Study, the Tango Bravo technology demonstration program is exploring design options for a reduced-size submarine with equivalent capability of the VIRGINIA Class submarine. The implicit goal of this program is to reduce platform infrastructure and, ultimately, the cost of future design and production of submarines. The program is a collaborative effort to overcome selected technological barriers that are judged to have a significant impact on submarine platform infrastructure cost. DARPA and the Navy, under Memorandum of Agreement, jointly formulated technical objectives for critical technology demonstrations in: (1) shaftless propulsion, (2) external weapons stowage and launch, (3) conformal alternatives to the existing spherical sonar array, (4) radical ship infrastructure reduction technologies that eliminate or substantially simplify hull, mechanical and electrical systems, and, (5) automated attack center technologies to reduce crew manning.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-02	

(U) Following success of shaftless propulsion technologies demonstrated in the Tango Bravo program, DARPA and the U.S. Navy will design, build, and test a large scale Shaftless Propulsion Submarine Demonstrator to characterize and mitigate risks associated with ship integration into a next generation submarine propulsion option. The Demonstrator will be built to the minimum scale necessary to extrapolate hydrodynamics, powering, and acoustics to full-scale performance. The most cost effective technical approach to developing the demonstrator design will be considered, including the modification of existing sub-scale submarines, while preserving the technical validity of the design features.

(U) Elements of the Tango Bravo program will begin transition to the Navy in FY 2009, with full transition anticipated at the conclusion of the Shaftless Propulsion Submarine Demonstration in FY 2011.

(U) Program Plans:

- Tango Bravo
  - Develop shaftless propulsion concepts and demonstrate required technologies at an appropriate scale to validate key aspects such as system size and weight, propulsive efficiency, and acoustic and electromagnetic signatures, including predictive capability.
  - Develop external weapons stowage and launch concepts and conduct an integrated demonstration of the critical technologies required to meet launch hydrodynamics requirements while providing a safe stowage environment for a Mk48 ADCAP torpedo outside the pressure hull.
  - Investigate maintenance and health issues associated with prolonged weapon stowage away from manned access.
  - Analyze modeling to evaluate acoustic and shock performance requirements.
  - Develop and demonstrate a radical ship infrastructure reduction concept that relies on electric actuation of the rudder and stern planes instead of traditional hydraulic- mechanical movement of the ship's control surfaces.
- Shaftless Propulsion Submarine Demonstrator
  - Perform design studies and computational analysis to establish critical design parameters.
  - Develop demonstrator designs and assess build alternatives; select demonstrator design.
  - Perform subsystem testing and analysis.
  - Build demonstrator.
  - Demonstrate hydrodynamic and powering performance.
  - Demonstrate acoustic performance.

UNCLASSIFIED

R-1 Line Item No. 54

Page 25 of 26

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Network-Centric Warfare Technology PE 0603766E, Project NET-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Non-Linear Dynamics for ASW	2.500	0.000	0.000	0.000

(U) The field of nonlinear dynamics has matured sufficiently to allow applications to nonlinear and non-stationary signal processing problems. Nonlinear beamforming approaches will be applied to the Navy’s Advanced Extended Echo Ranging (AEER) airborne Anti Submarine Warfare (ASW) concept to enhance the effectiveness of active acoustics in the littoral ASW environment by improving the ability to detect weak signals in the presence of noise, interference, and reverberation.

- (U) Program Plans:
- Developed system requirements for the nonlinear Air Deployable Active Receiver (ADAR) beamformer.
  - Developed analytical formulation of the nonlinear ADAR beamformer array dynamics.
  - Developed high fidelity time series simulation data for evaluating nonlinear beamformer performance.
  - Developed quantitative assessment of potential improvement for realistic environments.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	167.962	188.781	196.462	219.407	223.535	227.519	230.919	230.919
Surveillance and Countermeasures Technology SEN-01	51.745	54.436	64.725	74.766	76.572	81.556	84.956	84.956
Sensors & Exploitation Systems SEN-02	116.217	134.345	131.737	144.641	146.963	145.963	145.963	145.963

**(U) Mission Description:**

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

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

(U) The Sensors and Exploitation Systems project develops and demonstrates advanced sensors, and exploitation technologies. These efforts provide warfighters with situational awareness and precision target identification. The project is driven by four needs: (1) countering camouflage, concealment and deception (CC&D) of mobile ground targets; (2) providing near-real-time, semi-automatic exploitation of wide-area moderate- and high-resolution imagery; (3) obtaining real-time, accurate battle damage assessment; and (4) accomplishing robust, precise identification, precision fire control tracking and engagement of high value targets.

**UNCLASSIFIED**

R-1 Line Item No. 55

Page 1 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E	

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
Previous President's Budget	186.746	205.519	221.442	219.805
Current Budget	167.962	188.781	196.462	219.407
Total Adjustments	-18.784	-16.738	-24.980	-.398
Congressional program reductions	-14.000	-10.738		
Congressional increases	0.000	0.000		
Reprogrammings	0.000	-6.000		
SBIR/STTR transfer	-4.784	0.000		

(U) **Change Summary Explanation:**

FY 2006	The decrease reflects the SBIR/STTR transfer and the Section 8040 rescission.
FY 2007	The decrease reflects congressional cuts to SEER, Super-Resolution Vision System, Augmented Aerial Sentry, Bipedal Detection and a reduction for Section 8106 Economic Assumptions and a reprogramming to the Joint DoD/DOE Munitions Program.
FY 2008	The decrease reflects a departmentally directed reduction in funding for the Joint DoD/DOE Munitions Program and completion of several sensors efforts including Frequency-Diverse Spatial/Spectral Sensor Exploitation, Tactical Sensor Network Technologies, and Dynamic Tactical Targeting.
FY 2009	The decrease reflects minor program repricing.

**UNCLASSIFIED**

R-1 Line Item No. 55

Page 2 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Surveillance and Countermeasures Technology SEN-01	51.745	54.436	64.725	74.766	76.572	81.556	84.956	84.956

**(U) Mission Description:**

(U) This project funds sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness, strike capability and battle damage assessment. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert 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.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Counter Underground Facilities (UGFs)	14.208	22.218	26.725	32.766

(U) Counter Underground Facilities (UGFs) are being increasingly employed to hide a variety of tactical and strategic functions, including command and control, leadership escapes and hides, missile and artillery protection, and activities associated with the manufacture and storage of weapons of mass destruction. The Counter-Underground Facilities (CUGF) program is developing technologies to both find and characterize UGFs: identification of facility function, pace of activity, pre-attack status of the facility, trans-attack activities and post-attack status. Techniques are being developed to determine locations of critical systems (power, water, airflow and exhaust vents), orientation and depth of structure, and pre-strike and post-strike changes in the substructure resulting from attack.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

(U) This program began by developing validated phenomenological models for a range of underground facilities (UGF) signatures: acoustic, seismic, electromagnetic (EM), chemical, multi/hyperspectral, and gravity/gravity gradient. These models enable the evaluation of multiple sensor/targeting concepts, and drive requirements for highly sensitive, advanced sensors, which operate at very low frequencies in order to reach deeply buried structures. The CUGF Unattended Ground Sensor System (CUGSS), demonstrated the use of multiple, networked ground nodes of multi-phenomenological sensors (EM, acoustic, seismic) for UGF monitoring and target characterization. Another element, Effluents for Vent Hunting, has evaluated the feasibility of finding vents from stand-off locations by exploiting the spatial, spectral, and temporal characteristics of the exhaust plumes. The Low-Altitude Airborne Sensor System (LAASS) is demonstrating the use of airborne EM, acoustic, and gravity sensors to rapidly find UGFs and map out their backbone structure. Techniques are also being developed for finding and mapping traces and portals of small tunnels used for movement among large facilities or buildings, and for surreptitiously crossing borders and security boundaries. The Cross-Border Tunnel (CBT) program is using seismic and electromagnetic tomography to detect and localize small tunnels. The Remote Interconnected Tunnel Assessment (RITA) program demonstrated stand-off hyperspectral sensing to determine portals and vents that are connected by tunnels underground. Other potential technologies to be included are precision thermal imaging and active surface seismic and electromagnetic approaches. These are particularly useful for small, relatively shallow, unimproved tunnels.

(U) To support the demonstrations of these concepts, the CUGF program is also developing or modifying E-field, B-field, acoustic, and gravity-based sensors and enhancing navigation communications and signal-processing systems and technologies as necessary to meet the node-localization, communications and data-exfiltration requirements. The CUGF technologies began transition to the United States Special Operations Command, Defense Threat Reduction Agency (DTRA), the Defense Intelligence Agency (DIA), the Army, and the Air Force in FY 2006 and will continue transition through the FY 2010 time frame.

- (U) Program Plans:
- Transitioned CUGSS technology to DTRA, Air Force, DIA, and the Army.
  - Demonstrated RITA technology at a U.S. military facility.
  - Transitioned RITA-Lite system to the U.S. Army Rapid Equipping Force.
  - Build test bed for evaluation of CBT and other CUGF technologies.
  - Develop designs and performance predictions for prototype LAASS sensor payloads (EM, acoustic, and gravity) for unmanned air vehicles (UAVs) and manned aircraft platforms.
  - Integrate LAASS sensor payloads onto low-altitude UAV and manned aircraft platforms and develop optimum flight pattern strategy.

UNCLASSIFIED

R-1 Line Item No. 55

Page 4 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

- Demonstrate LAASS prototype system in rural and urban environments.
- Develop and demonstrate small tunnel finding, localizing, and endpoint mapping capabilities of prototype, rapidly transitionable systems in the CBT and RITA programs.

	FY 2006	FY 2007	FY 2008	FY 2009
Strategically Hardened Facility Defeat	0.000	4.000	6.000	9.500

(U) Building upon the successes of this technology developed under the Counter Underground Facilities program, the Strategically Hardened Facility Defeat program will continue to develop alternative earth-penetrating technologies for the defeat of strategically hardened targets. The threat posed by the proliferation of hard and deeply buried targets with major strategic capabilities around the world is increasing dramatically. These strategically hardened facilities are used to harbor our adversaries' most dangerous assets including leadership bunkers, command and control functions, and weapons of mass destruction. However, because the size and weight of traditional earth penetrating weapons scale exponentially with the depth of the facility, current warhead penetration depths are and always will be insufficient to reach many of these targets. As a result, a strategic capability gap exists and new approaches to earth penetration and warhead delivery are needed. This program seeks to leverage recent advances in earth-penetrating technologies for full defeat of strategically hardened facilities. This program will transition to DTRA in FY 2011.

(U) Program Plans:

- Develop new penetration technologies capable of meeting deployable weight and size goals.
- Develop robust, self-contained aerial deployment options that can interface with existing air platforms.
- Develop the ability to sense and navigate to the targeted functional area.
- Develop packaging and integration technologies that can withstand harsh environments.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Visibuilding	7.030	11.218	15.000	16.000

(U) The Visibuilding program is developing technologies and systems for new surveillance capabilities of buildings, to detect personnel within buildings, to determine building layouts, and to locate weapons caches and shielded enclosures within buildings. Radar signals are being used to image static structures directly. Doppler processing of radar signals is also being exploited to find, identify, and perform feature-aided tracking of moving personnel within a building and also allow mapping of building pathways and stairways by monitoring traffic through buildings. Doppler resonances of the building structure are being examined to provide relevant mapping information and indications of floor loading. Multipath and propagation effects are modeled and iteratively compared with hypotheses of building structures to provide 3-D building maps and large concentrations of metal materials like weapons. This program is developing techniques to inject and recover probing waveforms and to unravel the complicated multipath in the return signals, to enable the mapping and characterization of buildings. Transition of component pieces to the Army's PEO Soldier and United States Special Operations Command will commence in FY 2009.

(U) The Radar Scope program is a quick-response effort to provide pre-production prototypes of hand-held through-wall personnel detection radar. It will be able to sense through common wall materials to detect potential enemies before warfighters enter a room or building. The final product is a small sensor with a simple interface that weighs less than two pounds including batteries. The unit detects individuals through typical non-metallic wall materials (e.g., concrete, concrete block, adobe, wallboard, plywood, etc.) up to twelve inches thick. Transition to the Army Rapid Equipping Force via PEO Soldier Sensor and Lasers is anticipated. Follow-up technologies have been requested for sniper self defense, tunnel inspection, perimeter defense, remote operations, and finding objects buried in walls.

- (U) Program Plans:
- Visibuilding
    - Evaluated candidate designs for wall-penetrating technologies for building layout and combatant localization.
    - Evaluate candidate technical approaches for monitoring building envelope integrity.
    - Evaluate technical approaches for building interconnects detection and assessment.
    - Carry out feasibility measurements and modeling.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

- Design, build, and test prototypes for use in full-scale demonstration.
- Radar Scope
  - Evaluated candidate designs for through wall motion detection.
  - Carried out feasibility measurements and modeling.
  - Designed, built and tested prototypes for use in full scale demonstration.
  - Transition for use in full-scale demonstration.
  - Develop extensions of this technology for new application areas.

	FY 2006	FY 2007	FY 2008	FY 2009
Surveillance and Threat Neutralization in Urban Environments	3.000	9.000	7.000	3.000

(U) This program will develop systems to demonstrate the detection and defeat of threats specific to conflict and stabilization operations in the urban environment. These threats include roadside bombs, car bombs, suicide bombers, snipers, rocket propelled grenades, and mortars launched from inside urban boundaries. Detection technologies under development include intercept and localization of unintentional radiated emissions of remote-control circuits; multi-static radars for standoff identifications of shrapnel-packed bombs; detection of anomalies in vehicle dynamics; standoff identification and localization of explosive vapors/effluents; high fidelity 3D mapping performed from a high altitude (>15,000 feet) airborne platform; and multi-mode integrated acoustic and radar-based systems to backtrack to the source of fire. Techniques to cause incomplete detonation of explosives; portable fast-erecting blast shields and technologies to non-destructively and reversibly control urban access routes are being explored. These capabilities will be transitioned to Army and Special Operations ground forces to support urban operations planning with an initial focus on the targeting and intelligence components in FY 2009.

- (U) Program Plans:
- Evaluate candidate technologies for wide-area/stand-off and choke-point/portal-screening applications.
  - Prove feasibility in lab on sub-scale tests.
  - Design, build, and test prototype for choke-point applications and wide-area applications.

**UNCLASSIFIED**

R-1 Line Item No. 55

Page 7 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Integrated Sensor Is Structure (ISIS)	18.000	0.000	0.000	0.000

(U) The Integrated Sensor Is Structure (ISIS) program is developing a sensor of unprecedented proportions that is fully integrated into a stratospheric airship and that will address the nation’s need for persistent wide-area surveillance, tracking, and engagement for hundreds of time-critical air and ground targets in urban and rural environments. ISIS is achieving radical sensor improvements by melding the next-generation technologies for enormous lightweight antenna apertures and high-energy density components into a highly-integrated lightweight multi-purpose airship structure – completely erasing the distinction between payload and platform. The ISIS concept includes 99% on-station 24/7/365 availability for simultaneous Advanced Moving Target Indicator (AMTI) (600km) and Ground Moving Target Indicator (GMTI) (300km) operation; 12-plus months of autonomous, unmanned flight; hundreds of wideband in-theater covert communications links; plus CONUS-based sensor analysis and operation. The ISIS technology is planned for transition to the Army's PEO-ASMD, Air Force Joint Warfighter Space and the Missile Defense Agency by FY 2011. This program now resides in PE 0603287E, Project SPC-01.

- (U) Program Plans:
- Developed objective system concept designs enabling simultaneous AMTI and GMTI operation, one year logistics-free operation, 99% on-station availability, and high-bandwidth covert communications.
  - Identified specific mass-reducing technologies for key radar, power, and airship components.

	FY 2006	FY 2007	FY 2008	FY 2009
Radiation Detection (Formerly NUCTRAC)	3.000	0.000	0.000	0.000

(U) The Radiation Detection program investigated new technologies and systems to advance and enhance DoD capabilities in the area of hostile nuclear activities. In particular, this program considered technologies to improve radiation detection and tracking.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

- (U) Program Plans:  
 – Completed initial technology assessment.

	FY 2006	FY 2007	FY 2008	FY 2009
Hostile Fire Indicator (HFI)	3.957	2.000	0.000	0.000

(U) The Hostile Fire Indicator (HFI) program will develop an airborne extension of the Boomerang Rapid Response program to provide rotorcraft with situational awareness of small arms fire. Currently, pilots may be unaware that they are receiving small arms fire until it impacts in the vicinity of the crew cabin or some other critical and monitored system. The HFI system was initially designed to detect and locate the source of any small arms projectiles passing within meters of aircraft with a high probability of detection and precise source-location accuracy.

- (U) Program Plans:  
 – Measured acoustic/vibrational frequency background noise on one U.S. Army and two SOF helicopters.

	FY 2006	FY 2007	FY 2008	FY 2009
Speckle Exploitation for Enhanced Reconnaissance (SEER)	0.000	4.000	7.000	8.500

(U) The Speckle Exploitation for Enhanced Reconnaissance (SEER) program will provide long-range non-cooperative identification of moving/stationary targets using incoherent scattered laser speckle reflected off a target surface. Laser speckle has reduced sensitivity to adverse turbulence-induced distortion and so should provide a viable signal at ranges exceeding those projected for other active laser systems. Technical achievements under other programs in this PE/Project provide the basis for radically new approaches to measuring target characteristics under conditions that limit the performance of conventional sensors. Target characteristics potentially obtainable may include target image, shape, size, structural features, and other advanced threat properties. By extending the operating range of current active electro-optic sensors, SEER enables the friendly platform to stand off from the maximum operating range of hostile sensors/weapons, while executing the targeting task and directing weapons against targets. Transition to the Army is expected to occur by FY 2012.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

- (U) Program Plans:
- Develop algorithms that reliably and uniquely associate target signatures with speckle patterns.
  - Perform major system design trades.
  - Implement algorithms using optical MEMs or other related technologies to achieve reduced size, weight and power.
  - Design, develop, field, and test a prototype system on a tactical vehicle.

	FY 2006	FY 2007	FY 2008	FY 2009
Rescue Transponder	2.000	2.000	0.000	0.000

(U) Building upon technologies developed in other sensor programs, the Rescue Transponder (RT) program will investigate the use of covert localization and tracking technology to provide a very low probability of detection (LPD) call for help signal. The system is expected to use a wide band radio frequency signal with low power and extremely low duty cycle. The goals of the RT Program are to develop a small, rugged, transponder that provides a call for help to friendly forces. The RT system will operate over ranges that enable rescue forces or surveillance systems to receive its signals. It will support accurate localization by rescue forces, and permit transmission of identifying, authenticating, and status information. The Rescue Transponder technology is planned for transition to the Army in 2007.

- (U) Program Plans:
- Developed tags that enable the user to be identified and localized by airborne or advantaged receivers.
  - Designed a custom digital and microwave integrated circuit to allow tag miniaturization.
  - Built and tested prototype tags and transmitters.
  - Author viable manufacturing plans.
  - Conduct airborne demonstration and complete interference and LPD assessment to demonstrate military utility to transition partner.
  - Complete transition MOA between DARPA and Army.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

	FY 2006	FY 2007	FY 2008	FY 2009
Bioluminescent Signature Reduction	0.000	0.000	3.000	5.000

(U) Turbulence from vessels moving through the water stresses dinoflagellates and other single and multi-cell organisms causing them to emit light. This bioluminescent effect is readily visible under favorable circumstances providing a signature of the moving vessels. The goal of the Bioluminescent Signature Reduction program is to mitigate this effect through both inhibition of bioluminescence processes and masking of bioluminescent emissions. This new effort will include development of inhibition and masking technologies, bioluminescence sensors, delivery mechanisms for the mitigation technologies, and sea trials for testing the prototype system. Additionally, there will be continued development of a bioluminescence signature model, which is an empirically-based, time-dependent detectability model (range, cell concentration, and environmental). Recent developments in characterization of bioluminescent organisms and materials technology will be leveraged by the performer community in meeting the goals of this program. Transition partners may include the SOCOM Program Executive Office, Naval Systems, and the Special Naval Warfare Command.

(U) Program Plans:

- Explore prospective mitigation strategies involving engineering, materials, and concepts of operation.
- Develop detectability model for bioluminescent emission visualization.
- Identify and validate material approach for bioluminescent masking.
- Develop bioluminescence process inhibition technologies.
- Incorporate advanced algorithms into detectability model development.
- Develop system component concepts for countermeasure delivery and monitoring sensors.
- Integrate technology development, sensor, and modeling prototypes into a full-scale prototype system.
- Conduct sea trials and demonstration of the prototype system.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-01	

	FY 2006	FY 2007	FY 2008	FY 2009
RF MEMS Improvement	0.550	0.000	0.000	0.000

(U) RF MEMS switches in the X, Ka, and Ku band hold great promise for DoD radar applications due to their inherent small size, light weight, low power consumption and low loss. The RF MEMS Improvement program has extended lifetimes, developed inexpensive packaging techniques, and enhanced RF performance of RF MEMS switches to allow use in devices such as phase shifters, reconfigurable apertures, and tunable filters. The RF MEMS Improvement program is transitioning via industry to phased array antenna, reconfigurable communication front-end, seeker, and steerable aperture programs being developed by the Army, Navy, and Air Force.

- (U) Program Plans:
- Demonstrated fully integrated switch circuits (e.g., fully integrated phase shifters, switchable filters) with substantially better performance than discrete switch approaches.
  - Demonstrated integration of RF MEMS switches together with integrated transistor circuits to realize compact, single-chip systems.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>						<b>DATE</b> February 2007		
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Sensors & Exploitation Systems SEN-02	116.217	134.345	131.737	144.641	146.963	145.963	145.963	145.963

**(U) Mission Description:**

(U) The Sensors and Exploitation Systems project develops and demonstrates advanced sensor and exploitation technologies to provide accurate situational awareness and precise target identification. The project is driven by five needs: (a) integrating data from multiple sources into consistent situation assessments; (b) countering camouflage, concealment and deception of mobile ground targets; (c) providing near-real-time semi-automatic exploitation of wide-area moderate- and high-resolution imagery; (d) obtaining real-time, accurate battle damage assessment; and (e) accomplishing robust, precise identification, precision fire control tracking and engagement of ground targets. These needs are addressed in eight thrusts: 1) Soldier-borne Sensor Technology, to improve individual soldiers' situational awareness and effectiveness; 2) Ground Targeting Sensors, to increase our ability to detect close-in ground targets; 3) Advanced Airborne Optical Sensing, to provide high-resolution images over large areas; 4) Advanced Radar Sensing Technology, to observe targets at night and in bad weather; 5) Target Identification Technology, to build tools to automatically identify targets; 6) Pattern Analysis Technology, to distinguish suspicious movement and activity from benign clutter; 7) Network Centric Sensing and Engagement, to explore novel processing architectures enabled by the proliferation of data links; and 8) Persistent Exploitation, to combine sensors and exploitation tools in an integrated system to address counter-insurgency missions.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Soldier-borne Sensor Technology	16.245	15.273	14.465	13.000

(U) The Soldier-borne Sensor Technology thrust provides sensors for improved situational awareness and effectiveness of individual soldiers. It builds small unit enemy weapon fire detection and classification tools, more precise target designation sensors, and methods for improved small arms weapon effectiveness. Programs in this thrust include:

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02	

- The High Precision Long Range Laser Designator/Locator (HPLD) program seeks to develop an affordable laser target designator/locator package that allows the user to observe, track, and designate a target at operationally significant ranges. The focus of this effort is to investigate target-in-the-loop active optics approaches and novel high accuracy pointing methods to enable a single operator to precisely determine the GPS coordinates of a target that is multiple kilometers away. Once precisely determined, the operator will be able to observe, track, and laser designate the target as required, using a single device. This device will be used by ground combat elements and small unmanned aerial vehicles that conduct terminal attack control and call for fire and will be designed to support their full range of deployment methods. It will also survive in a harsh environment for long periods of time with minimal maintenance. This program will also investigate advanced, lightweight inertial navigation system (INS) technology, infrared imaging and advanced on-focal-plane processing technology to achieve revolutionary improvements in targeting device form factor, speed, cost and accuracy. The High Precision Long Range Designator/Locator technology is planned for transition to the Army and U.S. Special Operations Command (SOCOM) by FY 2009.
- The Omni-Directional Flash & Launch Detection, Positioning, Classification and Observation System (MEGA) program will develop a low-cost, omni-directional staring, infrared sensor, which will provide circumpheral imagery of its surroundings. The MEGA sensor and algorithms will be used to detect weapon discharges in its field of regard, locate and classify them and, using appropriate communication means, convey the information to other units or systems connected to it. This program will transition through delivery of two final 360 degree mobile systems to Service partners.
- The Crosswind Sensor System for Snipers (C-WINS) program provides optical techniques to correct for crosswinds on ballistic objects. The C-WINS System develops a novel weapon mounted laser correction system for various rifles and machine guns. This laser will be directed downrange for wind profiling and ballistic correction. The new system will provide offset corrections to the shooter for compensating the aim point affected by the crosswind. Key parameters of interest are: a) bullet strike coordinates less than the target size at any range up to weapons effective range; b) down range profiling up to weapons effective range; c) ranging accuracy sufficient to offset; d) automatic ballistic correction; e) day/night operation; and f) no setup or calibration. Additional capabilities could include: increased effective ranges for a wide range of weapons; eye safe ranging; illumination when combined with night sight; combat ID; and point-to-point voice communications. This program is planned for transition to the Army and Marines in 2010.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

(U) Program Plans:

- High Precision Long Range Designator/Locator
  - Built and demonstrated target-in-the-loop adaptive optics ability to achieve high resolution laser pointing and imaging of small targets.
  - Validated the pointing accuracy of eye safe integrated optics at targets multiple kilometers away.
  - Design, build, and demonstrate an integrated system of low weight and volume that validates the ability to be deployed and erected by dismounted troops.
  
- Omni-Directional Flash & Launch Detection, Positioning, Classification and Observation System (MEGA)
  - Develop and demonstrate IR sensor prototype.
  - Develop and demonstrate stationary omni system.
  - Develop and demonstrate mobile platform omni system.
  - Integrate mobile system with vehicle and demonstrate in series of field tests.
  
- Crosswind Sensor System for Snipers (C-WINS)
  - Develop atmospheric turbulence statistical model and investigate commercial off-the-shelf (COTS) lasers to test concept feasibility by modeling and field testing.
  - Develop system concepts that rely on tracking the aerosol motion resulting from crosswind over time.
  - Design and build an electronics board sufficient to trigger laser at required rates, receive, store and process data (on line and offline).
  - Integrate system and conduct field tests to validate the proposed concept as a function of the crosswind and scintillation index.
  - Develop and build three prototype C-WINS systems and integrate and test system in the lab and field.
  - Develop transition and manufacturing plan.

UNCLASSIFIED

R-1 Line Item No. 55

Page 15 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

	FY 2006	FY 2007	FY 2008	FY 2009
Ground Targeting Sensors	0.000	10.759	17.540	22.102

(U) The Ground Targeting Sensor thrust provides sensors and signal processing systems to detect, identify, and engage close-in ground targets. Its products are installed on platforms that operate on the ground (HUMVEE, convoy elements) and near the ground (helicopters). They employ technologies that defeat or compensate for the unusual atmospheric conditions near the surface (turbulence, dust, strong propagation losses) in order to provide timely and accurate detection and classification of dismounts, small vehicles, and terrain obstacles. Programs in this thrust include:

- The SandBlaster program is developing a passive pilot enhancement system that fuses visible, infrared (IR) and millimeter wave radiation to enable multiple helicopters to land safely in conditions of severe brown- and white-out. SandBlaster will exploit the low attenuation property of dust (fog and snow) on millimeter wave radiation. A passive millimeter wave system will be developed to preclude detection and prevent interference as would be expected from multiple active systems operated in close proximity. Four fundamental piloting situational awareness enablers will be addressed: (1) pilot’s ability to “see” in limited visibility conditions, (2) pilot’s awareness of helicopter drift, (3) pilot’s awareness of slope of terrain, and (4) display technology matched to mission and human factors considerations. The technology developed under this program will transition to SOCOM and the Marine Corps in FY 2008.
- The Super-Resolution Vision System (SRVS) program will develop and build a field prototype soldier-portable optical system that will demonstrate improved recognition and identification range over existing systems. The key technical innovation is exploitation of atmospheric turbulence-generated micro-lensing phenomena to generate better than diffraction-limited images. SRVS will facilitate new operational and tactical opportunities for land forces. Through enhanced resolution imaging, SRVS will (1) extend target recognition and identification to decisively longer distances; (2) overcome atmospheric turbulence, which now limits the ability of high-resolution optics; and (3) increase target identification confidence to reduce fratricide and/or collateral damage. It will culminate in a field demonstration of a prototype. Technology developed under this program will transition to the Services in 2010.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- Polar Bear will provide a missile seeker that uses polarimetric processing and 3-D registration with target folders to generate precision terminal guidance. The system will sense polarimetric long-wave infrared signals generated by target and background, derive the surface shapes of the target and background and match the target shape to 3-D target folders. This will enhance target identification capabilities and enable precision aim-point selection on the target. The program will develop algorithms for surface normals and shape signature extraction from polarimetric data, develop tools for 3D target folders, and develop software for real time onboard processing. The precision attainable by Polar Bear will be suitable for a kinetic-kill weapon and the sensor cost will be comparable to existent uncooled infrared missile sensors. Technologies are planned for transition to the U.S. Army.
- The Short Wave Infrared through Fog (SWIF) program will develop and demonstrate advanced signal processing and optical imaging technology to allow detection of collision and grounding threats in fog at useful ranges (day or night). Fog substantially degrades performance in precision handling operations. Humans are able to operate successfully with sensor assistance, but situational awareness degrades significantly with fog. Successful development of this technology will restore this situational awareness to tactically relevant distance and time scales. Technology developed under this program will transition to the Navy in 2012.

(U) Program Plans:

- SandBlaster
  - Tested attenuation properties of dust on active and passive millimeter wave imaging and developed system requirements.
  - Develop and identify an end-to-end system to provide the pilot with required situational awareness to land safely in multi-platform operations.
  - Integrate the system and demonstrate capabilities.
- Super-Resolution Vision System (SRVS)
  - Investigate optimal control algorithms and implementation using optical MEMs and chip-based technologies.
  - Perform system design.
  - Design and develop a brassboard prototype for laboratory and field experimentation and developmental testing.
  - Integration into a prototype soldier-portable optical system.

UNCLASSIFIED

R-1 Line Item No. 55

Page 17 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- Polar Bear
  - Conduct long-wave infrared measurements of various targets over a range of employment conditions, including geometry, lighting, obscurants, etc.
  - Develop and evaluate polarimetry-based 3-D registration algorithms.
  - Develop algorithms and exploitation tools for target folder development based on processed sensor data.
  - Conduct preliminary design review for a Polar Bear enabled missile seeker to be built and demonstrated.
  - Develop a concept for operations and identify transition opportunities for the Polar Bear seeker technology.
  
- Short Wave Infrared through Fog (SWIF)
  - Develop and demonstrate imaging algorithms.
  - Demonstrate image formation capability in a brassboard system.
  - Design, develop, and test a prototype system.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Airborne Optical Sensing	19.700	26.389	25.100	26.000

(U) The Advanced Airborne Optical Sensing thrust develops large aperture sensors and image processing systems to provide video coverage of large areas. It builds optics, gigapixel focal plane arrays, embedded image processors, and video compression algorithms tailored to real-time detection, identification, and tracking of military targets. It emphasizes materials and phenomenologies suitable for operations at night and with significant atmospheric absorption. Programs in this thrust include:

- Standoff Precision ID in 3-D (SPI 3-D) program is developing an affordable sensor package capable of high-resolution 3-D images for confirmatory target ID at long ranges (>10km). The SPI-3D sensor overcomes obscuration and penetrates foliage, camouflage, and fog layers via range gating and control of incident pulse energy density. The system provides intensity, range and polarization information for each pixel in the field of view with each laser pulse. The program includes a series of ground-based and airborne demonstrations of SPI-3D precision ID capabilities and track fusion techniques. The objectives are to provide: (1) high range resolution imaging; (2)

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02	

intensity mapping; and, (3) polarization exploitation. Results will provide commanders with significantly improved long-range identification of enemy ground targets, both stationary and moving. The SPI-3D sensor system employs existing commercial-off-the-shelf optics, focal plane arrays and gimbals, combined with a novel Pockels cell range measurement technique. The SPI-3D technology is planned for transition to the Air Force at the conclusion of Phase IV, which is anticipated to be completed by FY 2010.

- The Synthetic Aperture Ladar for Tactical Imaging (SALTI) program develops and demonstrates an airborne synthetic advanced laser radar (ladar) imager capable of producing high-resolution three-dimensional imagery at long ranges. The SALTI approach combines the long-range day/night access afforded by conventional synthetic aperture radar with the interpretability of high-resolution optical imagery and the exploitability of three-dimensional imagery, for deployment within a tactical-sized package. The technical objective of the SALTI program is to provide a proof-of-concept for operation at tactically relevant high altitudes and at long ground ranges. Development and demonstration of long range performance is scheduled to be conducted through FY 2009. The SALTI technology is planned for transition to the Air Force by FY 2010.
- The Advanced Optical Sensing program develops the next generation of airborne optical surveillance systems while also developing and demonstrating the ability to obtain very high dynamic range, high resolution hyper-spectral and polarimetric information from airborne imagers. The program focuses on bringing recent advances in photonic and other technologies to military airborne optical sensing systems. This effort develops advanced digital signal processing to support onboard image reconstruction, atmospheric correction and system calibration. Techniques are being explored to realize a large aperture wide-field-of-view imaging system within less than half a meter of thickness. Adaptive optics techniques, such as those used for atmospheric correction, are being explored to help combine sub-apertures while relieving alignment requirements. While electronic beam steering and zoom optics have been demonstrated with deformable mirrors and liquid crystal spatial light modulators, this program seeks to extend these technologies and make them practical for airborne surveillance systems. Technologies are planned for transition to the U.S. Army.
- The Large Area Coverage Search-while-Track and Engage (LACOSTE) program enables persistent tactical-grade Ground Moving Target Indication (GMTI) in dense urban areas. Wide-area continuous tracking of moving vehicles requires very small coverage gaps, small resolution cells, and target separation and identification features. The ideal sensor has the area coverage rates of GMTI radar and the resolution/identification capabilities of an electrooptical infrared system. The LACOSTE program will provide wide area surveillance, simultaneous tracking, and target engagement with optical and infrared sensors for tactical GMTI operations. The program is developing

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

a sensor with a very wide field of regard (90° cone angle), and a wide instantaneous field-of-view (FOV) that is rapidly scanned in a search-while-track mode – tracking up to 10,000 targets in an urban area. Additionally, the LACOSTE sensor will provide next-generation precision tracking to enable engagement on a large number (~100) targets in dense urban areas within that same field of regard with a minimal penalty on the search-mode area coverage rate. The program is also developing a rapid “zoom” capability for target identification that enables feature-aided tracking through dense target environments plus sufficient target identification for separating like-targets when back-tracking a particular target via the historical track data. The LACOSTE technology is planned for transition to the Air Force and the Army at the conclusion the program anticipated in FY 2009.

(U) Program Plans:

- Standoff Precision ID in 3-D (SPI-3D)
  - Determined precision of ranging technique in a field environment.
  - Integrate and demonstrate system from manned aircraft against stationary and moving targets.
  - Conduct confirmatory tests to demonstrate utility of the SPI-3D sensor system under a wide range of environments and target conditions.
  - Integrate SPI-3D technologies into a unmanned air vehicle (UAV) compatible prototype system.
  - Transition SPI-3D sensor technologies and system concept to the Services.
- Synthetic Aperture Ladar for Tactical Imaging (SALTI)
  - Completed sensor packaging and ground testing.
  - Completed Early Flight Tests, which produced the first-ever Synthetic Aperture Ladar high-resolution image images from aircraft.
  - Refined image formation processing algorithms to coherently combine multiple laser pulse returns and to compensate for platform motion during the collection of these multiple pulses.
  - Characterize coherent infrared propagation through the atmosphere under operational conditions, to assess the feasibility of long range operation.
  - Develop lasers for higher power and higher bandwidths to support Long Range Demonstration (LRD).
  - Demonstrate, in LRD, SALTI performance at operationally significant ranges on contractor-owned airborne testbed.

UNCLASSIFIED

R-1 Line Item No. 55

Page 20 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- Advanced Optical Sensing
  - Investigate approaches for producing large aperture imaging systems with constrained size.
  - Explore uses of adaptive optics to provide optical corrections for multiple sub-apertures.
  - Investigate technologies for optical beam steering and optical zoom that can be applied to airborne optical systems.
  - Develop advanced signal processing techniques for the rapid formation of optical imagery.
  - Design, build and demonstrate next generation airborne surveillance system.
  - Incorporate state-of-the-art automatic target recognition capabilities into a chosen system.
  - Transition system to Services for production and fielding.
  
- Large Area Coverage Search-while-Track and Engage (LACOSTE)
  - Develop objective system concepts enabling wide-area stand-off sensor for urban tactical-grade ground target tracking.
  - Develop electrooptical infrared electronically scanned sensor components.
  - Develop optical tracking algorithms.
  - Lab test the sensor parameters against measured urban data.
  - Manufacture and integrate the LACOSTE sensor components.
  - Conduct a rooftop demonstration of a large cone-angle electronically scanned sensor in an urban environment.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Radar Sensor Technology	8.000	12.000	15.000	20.000

(U) The Advanced Radar Sensor Technology thrust develops radar systems to provide significant improvements in our ability to detect, identify, and track surface targets and threats over very wide areas in all climatic conditions. Program efforts focus on exploiting emergent and novel radar sensing technology and phenomenology. Key elements are advancements in ultra-wide band, bistatics, UHF/VHF, polarimetric change detection, tomographic imaging, space-time adaptive processing and other advanced signal processing, advanced Ground Moving Target Indication techniques, and foliage, building-penetrating, and ground-penetrating radar phenomenology. Program developments are integrated with current and emerging military platforms. Emphasis is on the most stressing military radar sensor challenges. Examples are operations featuring

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02	

complex cluttered ground environments; those against small and slow moving surface targets; urban operations, and situations where camouflage, decoys and countermeasures must be overcome. Programs in this thrust include:

- The Augmented Aerial Sentry (AAS) program develops a rapidly-deployable airborne system to provide assured protection of permanent or temporary U.S. base camps in hostile territory. AAS includes ground-based, wide area sensors in conjunction with air platforms to maintain continuous surveillance of the area around the camp, detecting potential intruders or weapon launches. The suite of airborne sensor platforms can be tasked locally to investigate potential threats; lock on to personnel or weapons involved in an attack; allow commanders to confirm threats; or authorize precision weapons to engage them. Technologies are planned for transition to the Air Force and Army.
- The Sensing and Exploitation of Urban Movers (SE-UM) (formerly Bipedal Detection) program develops technology for the detection of dismounted troops in combat situations using airborne radars. SE-UM develops the capability to detect, classify, track and recognize the behavior of human beings using radar data. Existing radars that have been shown to allow this capability under ideal circumstances; those under development will, either fortuitously or by design, more consistently obtain detections from individuals. SE-UM will exploit these data by detecting each individual, classifying the individual as human and according to their speed and gait, tracking many individuals (forward and backwards in time) and automatically recognizing common, anomalous and significant actions/behaviors. Challenges include detection of motion below the minimum discernable velocity of the radar system, and discernment of multiple moving objects within a single beam width. Using SE-UM on data from appropriately designed airborne radar the system could observe human motion over an entire urban region. SE-UM technologies will transition to the airborne systems deployed by the Air Force and Navy.
- The NetTrack program will extend capabilities for persistent tracking and targeting of moving vehicles from airborne radars. NetTrack will improve capabilities in two ways: the system will network radars together and use advanced radar techniques to gather “signatures” of vehicles. The signatures, which are collections of radar features, will be stored and passed over the radar network. The system will compare vehicle signatures taken before and after confusing events to maintain the track of the target vehicles. Extended long-term airborne radar tracking will be an important long-range, all-weather, capability. It will extend the kill chain to enable vehicle engagement hours after target designation, enable behavioral analysis of vehicle movements to gauge enemy operational structure, force composition, and intentions, and provide a higher level of situational awareness at every level. Technologies are planned for transition to the Navy, Army and Air Force.

**UNCLASSIFIED**

R-1 Line Item No. 55

Page 22 of 34

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- The Dual Beam Lynx program will enhance the capabilities of the Lynx radar system to track slow-moving vehicles more accurately. The program modifies a Lynx I radar to create two beams with different phase centers and uses space time adaptive processing to detect moving targets in the main beam clutter. The goals of this program include demonstrating improvement in minimal detectable velocity, improving geolocation accuracy, and achieving a low manufacturing cost. The radar performance will be demonstrated from flight data collected from the radar flying on a UAV surrogate.

(U) Program Plans:

- Augmented Aerial Sentry
  - Develop system architecture that will utilize existing and newly-developed sensing technologies to track potential and imminent threats.
  - Demonstrate effectiveness of system architecture.
  - Develop, demonstrate, and test system that incorporates multiple sensing technologies to provide situational awareness to commanders.
- Sensing and Exploitation of Urban Movers (SE-UM)
  - Develop algorithms to extract and classify dismount combatants walking, running, and other repetitive activities based on collected data.
  - Develop and evaluate algorithms for classifying human activities, e.g. walking, running, digging, carrying loads, etc.
  - Develop and evaluate algorithms for feature-aided tracking of dismounts based on characteristic signatures, e.g. gait parameters, human height, etc.
  - Develop concepts for operation and system architectures for the insertion of SE-UM modes into existing and future planned radar systems.
- NetTrack
  - Improve capabilities for using vehicle radar signatures to associate vehicle observations.
  - Demonstrate NetTrack operations in simulation.
  - Demonstrate radar signature-aided vehicle tracking, and the cooperative use between radar platforms of those radar features.
  - Demonstrate NetTrack capabilities in real-time on networked radar platforms.

UNCLASSIFIED

R-1 Line Item No. 55

Page 23 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- Dual Beam Lynx
  - Conduct Preliminary Design Review.
  - Develop algorithms.
  - Develop space time adaptive processing.
  - Perform flight test and data collection.

	FY 2006	FY 2007	FY 2008	FY 2009
Target Identification Technology	16.998	17.000	17.000	20.000

(U) The Target Identification Technology thrust develops semiautomatic methods to identify targets from sensors operating in all spectral bands. Its objective is to detect, characterize, and identify military threats, and to assess the environment around them. Data sources include national, theater, and organic sensors. Critical performance metrics are timeliness, accuracy, error rates, and interpretation workload. The thrust addresses the challenges of target identification, acquisition and tracking under restrictive rules of engagement. The technologies will apply advanced signal processing and machine vision to leverage advances in sensor capabilities. Programs in this thrust include:

- The Tactical Sensor Network Technologies (TSNT) program develops detection, tracking, identification, and pattern analysis capabilities that operate in all nodes (fixed or mobile) within a networked, distributed multi-sensor system. The processing to be performed at each network node depends on the sensors reporting to that node, the subscribing commanders, and resource management decisions. TSNT exploits locality of sensing, but will leverage the advantages of a self-forming adaptive network for signal processing. Algorithms are designed to be aware of the sensor network and adapt their processing algorithms based on self-discovered network topology. The algorithms also take into account power management constraints, communications bandwidth limitations, and constraints found in the local environment. TSNT is resilient to the failure of any node while maintaining sufficient consistency to support commanders' collaborative tactical planning. Technologies are planned to be transitioned to the U.S. Army (PEO IEWD).
- The Exploitation of 3-D Data (E3D) program has developed techniques for rapidly exploiting 3-D sensor data. The initial program effort consisted of three distinct processes: Target Acquisition, Target Recognition, and Modeling. The resulting software tools were integrated into operational ground stations processing 3-D sensor data. The E3D technology was transitioned to SOCOM in FY 2006. The 3D

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

Reasoning (3DR) initiative is a follow-on program to E3D which will develop techniques to automatically generate large, fully annotated 3D urban models from the rich sources of high-resolution laser radar data available from ground-based and airborne platforms. 3DR extends vehicle-centric automated target recognition methods to support the much broader class of objects accessible in urban and complex terrain - particularly side-looking sensors mounted on patrol vehicles. The program consists of four distinct components: (1) new methods to rapidly and precisely co-register 3D and 2D data from disparate ground and airborne sources; (2) new 3D recognition approaches that identify objects within a class based on limited initial training; (3) a flexible and expandable 3D database structure to support the highly detailed and evolving urban models and provide the basis for geometry-based queries; and (4) a user interface that provides rapid and flexible access to the data. The resulting software tools and modeling capabilities will be integrated into future command posts and operational SOCOM and Army units in the field at the conclusion of the program anticipated to be completed in FY 2011.

- The All-Source Target Characterization program develops a collection and measurement capability to characterize new targets as they emerge on the battlefield. This effort develops tools to permit rapid user interaction with imagery, sensor data, and processing results and provides real-time feedback to operators indicating target key features and other discriminates. The technology provides tools to process and disseminate target signatures to the field in usable formats for direct insertion into operational systems and enhances operator interfaces with extant analysis workstations to allow on-the-fly collection of signature data with little/no intervention for the operator. Technologies are planned for transition to the Air Force Distributed Common Ground Station in FY 2009.
- The Detect UAV program develops techniques to detect, track, and characterize small UAVs that are easily built, inexpensive, easy to operate, and offer the asymmetric adversary an ability to reach into well-defended locations causing potentially large amounts of damage. It includes signal processing techniques to detect small air targets in radar, video, acoustic, and passive radio-frequency intercepts; to correlate those data with known objects (e.g., civilian aircraft); to analyze the motion of any uncorrelated data; and to rapidly task narrow-field-of-view sensors to collect more-detailed data. It will transition to the Army in FY 2010 to meet both static force protection needs and tactical air defense operations.

(U) Program Plans:

- Tactical Sensor Network Technologies (TNST)
  - Develop algorithms for distributed situation assessment at all nodes of a networked group of sensors.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- Integrate and assess distributed system performance in large-scale simulation and limited-scale testing.
- Demonstrate robustness of TSNT networked sensing under network and environmental stresses.
- Incorporate tracking, target identification, and target assignment algorithms for fully distributed operation.
- Exploitation of 3-D Data (E3D)
  - Integrated E3D software into a fingerprinting system capable of identifying specific vehicle instances.
  - Extended model-based vision technologies to classify, identify, and characterize the operational state of ground targets from other sources of 3-D sensor data.
  - Provide high-resolution ground-based data sources to develop cross-platform data registration algorithms.
  - Develop new recognition algorithms to locate, identify, and annotate objects based on class properties.
  - Incorporate intelligent character recognition for sign reading in urban areas aided by 3D extraction methods.
  - Expand class recognition algorithms to hundreds of classes of objects in urban and complex terrain.
  - Improve processing time to fully annotate several square kilometer models in less than an hour.
  - Integrate natural language interface to allow warfighters to quickly access urban models with detailed queries.
- All-Source Target Characterization
  - Obtain a large set of target vehicles of extreme variety.
  - Characterize the shape, surface material, equipment, and mobility characteristics.
  - Obtain data on all vehicles in a scripted scenario representative of future threat operations.
  - Release data for a baseline set of vehicles to develop target models.
  - Conduct quarterly characterization exercises given a fixed time to develop a new set of target models from observed data.
  - Evaluate performance by comparing reconstructions with the shape, surface material, equipment, and mobility characteristics measured on the actual vehicles.
- Detect UAV
  - Generate candidate system architecture, focusing on an effective sensor suite, to detect and track small UAVs.
  - Perform quantitative system analyses to estimate detection rates and timelines.
  - Assemble a set of software tools to convert raw sensor data in to target detections.

UNCLASSIFIED

R-1 Line Item No. 55

Page 26 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- Build an all-source correlator to filter out detections from known aircraft and persistent clutter sources.
- Evaluate system performance on simulated data.
- Install a prototype system on a U.S. military base for testing.
- Support transition efforts to install at overseas facilities.

	FY 2006	FY 2007	FY 2008	FY 2009
Pattern Analysis Technology	15.000	13.000	9.000	8.000

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

- The Video Verification and Identification (VIVID) program develops technology to automate moving target strike operations for remotely piloted aircraft (RPA). Program products support both precision strike operations and military surveillance. VIVID enables the handoff of targets between wide area coverage Intelligence, Surveillance, and Reconnaissance systems and local video surveillance platforms. The technology provides techniques for precision target identification in video including fingerprinting techniques and related technology to permit reacquiring previously observed vehicles. The program also features techniques enabling video sensors to autonomously and simultaneously track multiple vehicular targets through dense traffic, temporary occlusion or exit from sensor field of view, in military surveillance and strike operations, and supports target detection of moving vehicles and/or dismounts in very low resolutions. VIVID significantly advances the capabilities of video surveillance and moving target strike for numerous military missions, including military operations in foreign urban areas. DARPA has established a MOA with the Air Force to transition the VIVID technology to the Predator. The VIVID technology is planned for transition at the conclusion of Phase II which is anticipated to be completed by the end FY 2008.
- The Dynamic Tactical Targeting (DTT) program develops sensor control and data fusion technologies to enable warfighters to manage a process to find, identify, track, target, and destroy mobile, time sensitive targets. Current targeting technology is too slow to maintain target track and support prosecution of these fleeting targets. DTT is designing and demonstrating a system that: 1) leverages existing

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

National/Theater Intelligence, Surveillance, and Reconnaissance (ISR) processes for timely extraction of critical data; 2) fuses organic sensor data with ISR data from all sources to continuously estimate target location, identity, and activity; 3) dynamically tasks standoff, organic, and embedded sensors to fill ISR coverage gaps and provide relevant sensor observation in areas of tactical interest; and 4) processes and manages the voluminous data produced by various sensors in time to provide the warfighter information required to prosecute time-sensitive targets. The DTT technology is planned for transition to the Air Force in FY 2008 after a series of tests conducted with the Air Force Transformation Center.

- The Forensic Target Motion Analysis program develops and demonstrates exploitation tools to analyze Ground Moving Target Indicator Radar tracks of multiple targets to separate militarily-interesting target movement (infiltrators, envelopments, defensive site preparation, logistics support) from nominal background traffic (e.g. civilians, coalition operations). It develops libraries of movement patterns, logic to generate hypotheses about which patterns are being observed, algorithms to correlate sensor data to those patterns, and mechanisms to quantitatively score the consistency of the data with each hypothesis. It also includes tools to provide short-term (5-10 minute) predictions of target motions, thereby supporting some forms of predictive threat analysis. The tools will be integrated into Distributed Common Ground Stations in FY 2010.

(U) Program Plans:

- Video Verification and Identification (VIVID)
  - Develop techniques to automate detection, classification, and tracking of enemy, mobile, surface targets in visible and infrared motion imagery acquired by remotely piloted aircraft (RPA).
  - Develop automated techniques to detect moving vehicles and dismounts in single or multiple fixed areas for ISR operations or final inspection of weapon strike areas.
  - Demonstrate integrated, semi-automated engagement of hostile surface targets with precision weapons guided by data from video sensors on airborne platforms.
- Dynamic Tactical Targeting (DTT)
  - Demonstrate human interaction with closed-loop control of fusion and sensor management in a simulation environment.
  - Develop rapid 4D registration of multiple tracks to enable continuous tracking of numerous targets.

UNCLASSIFIED

R-1 Line Item No. 55

Page 28 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- Develop information fusion methods and the capability to plan and replan appropriate sensor platforms; enable continuous track of multiple time-sensitive targets simultaneously.
- Develop end-to-end robust system capability with integrated DTT components in the Air Force Research Laboratory testbed.
- Develop system measures of performance for evaluations.
- Integrate the system with an existing Air/Ground Battlespace Simulator/Testbed and perform experiments.
- Complete a robust laboratory demonstration of the system.
- Build a system to test in field demonstrations.
  
- Forensic Target Motion Analysis
  - Obtain ground-truthed, wide-area Ground Moving Target Indicator (GMTI) data from operational airborne sensors.
  - Develop system architecture.
  - Create a set of motion pattern templates for both military and background activities.
  - Demonstrate capabilities to correlate real-time data to motion models.
  - Explore tools to semi-automatically delete, modify, and add models to the library.

	FY 2006	FY 2007	FY 2008	FY 2009
Network Centric Sensing and Engagement	20.683	19.662	13.000	12.361

(U) The Network Centric Sensing and Engagement thrust develops technology and tools to support precise situational awareness, rapid targeting, and precision engagement in highly-networked environments. Network-centric sensing acknowledges a group of sensors as a system and leverages networked intercommunication to enable system performance superior to that of uncoordinated individual sensors. Applications include advanced target detection, acquisition, tracking, and combat identification. The technology is suited to both ground-based sensors and airborne multi-ship sensor systems. Exploiting the potential of network-centric sensing requires a number of approaches. Required technology advances include: sensor-to-sensor communications, multi-sensor management, sensor system georegistration, real-time data fusion, advanced tracking, and network-centric sensor operational modes. Programs in this thrust include:

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor Technology PE 0603767E, Project SEN-02	

- The Camouflaged Long Endurance Nano-Sensors (CLENS) program develops low-cost, lightweight micro-sensors to detect, geolocate, track, and classify targets in difficult environments. The system leverages ultra-wideband radio technologies developed for advanced communications. The combination of active, coherent, distributed-network sensing offers unique capabilities not possible from stand-alone, single-point systems. CLENS enables reduced force protection and supports monitoring of borders and critical CONUS sites, and long-duration covert monitoring of target sites such as terrorist camps. CLENS has broad application in support of comprehensive intelligence, surveillance, and reconnaissance for situational awareness and enables persistent sensing of dismounted combatants in forested areas and other tough environments. The CLENS technology is planned for transition to the SOCOM at the conclusion of Phase III anticipated to be completed by FY 2007.
- The Quint Networking Technology (QNT) is a modular, multi-band, network data link program focused on providing capabilities that close the seams between five nodes - aircraft, unmanned combat air vehicles (UCAV), weapons, tactical unmanned air vehicles (UAV's) and air control ground units. The program designs, develops, evaluates and demonstrates robust, affordable data link technologies suitable for use by weapons, tactical UAV's, and air control units. This includes shrinking the package size of data link capabilities from the current 1000 in<sup>3</sup> to 10 in<sup>3</sup>, the size of a cell phone. These data links enable precision strike and efficient machine-to-machine targeting against time critical and mobile targets, support combat identification of targets, disseminate tactical UAV and ground sensor data, and provide bomb impact assessment (BIA). The data links allow secure weapon handoff from the launch platform to any of several control platforms in the combat area, both air and surface. The QNT units provide two modes: a low rate bi-directional mode and a high data rate mode capable of either continuous or a burst imagery/video transmission. Dynamic net resource management technology will scale to support hundreds of vehicles in flight. Advanced information security techniques provide secure weapon data links and controller handovers. QNT technology transitions via insertion into DoD's existing and emerging weapons, tactical UAV's, and tactical handheld units after the program is completed in FY 2008.
- The Target Geolocation from a UAV (GeoLoc) program uses novel photogrammetric techniques to provide accurate geolocation of ground targets (<10 meters CEP) from small and mid-size UAVs. This represents an order of magnitude improvement in accuracy compared to instrumentation used on high-end UAVs. Further it requires no new hardware on-board the aircraft and does not rely upon prepared reference imagery. This photogrammetric technology will permit UAVs to not only observe targets for the first time, but also to direct fire from coordinate-seeking weapons. Furthermore, the technology will be extended to provide real-time geolocation on moving vehicles as well, enabling engagement of moving targets without use of laser designators, and without any human operators in harms way.

**UNCLASSIFIED**

R-1 Line Item No. 55

Page 30 of 34

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

The thrusts and future capabilities of the GeoLoc Program are: detection, precision identification, tracking, and destruction of elusive surface targets from networked manned and unmanned systems. Technologies are planned for transition to the Air Force.

- The Wide Area Video Exploitation program will develop technology to enable wide field-of-view visible and infrared imagery (EO/IR) framing cameras in airborne platforms to detect and track, in real time, multiple moving objects under a wide range of conditions and topography. Current systems are able to collect data and provide an ability to backtrack individual targets post-facto. The Sonoma-Plus program aims to provide a real-time ability to track in forward time multiple potential targets from high-altitude video imagery. On-board processing will be crucial since imagery data volumes will amount to gigabytes per second. Multi-hypothesis tracking of dozens and eventually hundreds of entities will also be developed, and imagery stabilization based on prior digital elevation models will also facilitate tracking and track analysis. Technologies are planned for transition to the Army.

(U) Program Plans:

- Camouflaged Long Endurance Nano-Sensors (CLENS)
  - Developed tracking algorithms to consolidate range-only detects into contact tracks.
  - Fabricated targeted form factor micro-sensors.
  - Conducted ground demo with one receiver/processor and many micro-sensors.
- Quint Networking Technology (QNT) (formerly Rotorcraft SIGINT/COMINT Geolocation)
  - Conduct analysis, design and hardware-in-the-loop tests.
  - Build and evaluate brassboard in stage 1 tests.
  - Cycle and test brassboard Stage 2 tests and flight tests.
- Target Geolocation from a UAV (GeoLoc)
  - Evaluate platform noise models.
  - Demonstrate reliable point feature extraction.
  - Integrate with UAV telemetry.
  - Demonstrate real-time geolocation from airborne video.
  - Integrate and transition to Common Ground Station.

UNCLASSIFIED

R-1 Line Item No. 55

Page 31 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

- Extend algorithms for geolocation of moving targets.
- Demonstrate real-time geolocation of moving targets.
  
- Wide Area Video Exploitation
  - Evaluate imagery and algorithms to perform stabilization and multi-hypothesis tracking.
  - Build video processing architecture to demonstrate an ability to track 50 or more moving entities in playback mode of 50 Megapixel video data with a frame rate of at least 1 Hz.
  - Integrate computer architecture with a collection platform to provide tracking over hundreds of entities simultaneously in 100 Megapixel (or higher) video data.

	FY 2006	FY 2007	FY 2008	FY 2009
Persistent Exploitation	19.591	20.262	20.632	23.178

(U) The new Persistent Exploitation program integrates a wide variety of sensors, data links, exploitation tools, correlators, and pattern analyzers into an end-to-end capability, focusing on counter-insurgency missions. These missions must be supported at all hours of the day, over large areas, and against a diverse set of targets, characteristics that no homogeneous sensor architecture can address. It ties separate hardware and software components together so that interactions among them can be defined, assessed, evaluated, and refined. It emphasizes real-time testing in realistic environments (e.g., the National Training Centers) so that subtle dependencies and interactions can be discovered.

(U) The Persistent Operational Surface Surveillance and Engagement (POSSE) program creates a system of systems framework in which a mix of surveillance assets, both operational and developmental can be coordinated and exploited to yield persistent surveillance of insurgent activities. The program focus is on the Iraqi theatre, using a spiral approach designed to insert enhanced counter-insurgency capabilities into operational use as soon as possible, followed by improvements and enhancements as they become integrated through a domestic testbed. The efficacy and timeliness of surveillance afforded by the program's systems-level approach will significantly exceed that afforded by individual ISR components, and will result in substantially enhanced force protection for fixed sites, convoys, and military operations. The framework includes data exploitation at both forward-deployed and national sites to support both quick-reaction cuing to engage insurgents, and deeper forensic

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Sensor Technology PE 0603767E, Project SEN-02	

analysis to identify their support structures. The POSSE program is jointly funded with the Joint Improvised Explosive Device Defeat Task Force. POSSE technologies are planned for transition to the U.S. Army Intelligence and Security Command.

(U) Program Plans:

- Conduct a comprehensive analysis of existing surveillance assets in the Iraqi theatre.
- Develop a systems architecture and asset utilization plan that maximizes persistent surveillance capability in high priority regions, based on currently available assets.
- Identify coverage and gaps and required new capability needed to satisfy persistent surveillance and force protection objectives.
- Define a spiral development plan that emplaces initial capability in theatre as early as possible, and identifies needed enhancements and new capabilities to be inserted in subsequent phases.
- Initiate accelerated development of gap-filler sensors and/or platforms.
- Develop an integrated capability to exploit all theatre-deployed ISR assets in a coordinated, systematic manner.
- Test an initial POSSE exploitation system at the National Training Center.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

R-1 Line Item No. 55

Page 33 of 34

**UNCLASSIFIED**

**THIS PAGE INTENTIONALLY LEFT BLANK**

**UNCLASSIFIED**

R-1 Line Item No. 55

Page 34 of 34

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Guidance Technology PE 0603768E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	87.989	142.826	127.777	121.704	110.969	101.597	103.597	103.597
Guidance Technology GT-01	40.773	53.464	44.856	30.707	30.500	30.000	30.000	30.000
Classified GT-CLS	47.216	89.362	82.921	90.997	80.469	71.597	73.597	73.597

**(U) Mission Description:**

(U) The Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing system oriented technologies that will improve our ability to navigate weapon systems with more precision and increase the capability to meet current and emerging threats.

(U) The Guidance Technology project will increase the ability of Global Positioning System (GPS) users to operate effectively in the presence of enemy jamming; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems. Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this project.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E	

(U) <b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b> <b><u>FY 2007</u></b> <b><u>FY 2008</u></b> <b><u>FY 2009</u></b>
Previous President's Budget	101.797    157.367    159.094    155.760
Current Budget	87.989    142.826    127.777    121.704
Total Adjustments	-13.808    -14.541    -31.317    -34.056
Congressional program reductions	-10.000    0.000
Congressional increases	0.000    -14.541
Reprogrammings	-1.200
SBIR/STTR transfer	-2.608

(U) **Change Summary Explanation:**

FY 2006	The decrease reflects the SBIR/STTR transfer, a reprogramming action to support the Department's Advanced Concept Technology Demonstration program, and the Section 8040 rescission.
FY 2007	The decrease reflects an execution adjustment and a decrease for Section 8106 Economic Assumptions.
FY 2008/2009	The decrease reflects the ending of Advanced Gyroscopes and reduced funding in navigation programs that will begin transitioning in this timeframe.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development				<b>R-1 ITEM NOMENCLATURE</b> Guidance Technology PE 0603768E, Project GT-01				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Guidance Technology GT-01	40.773	53.464	44.856	30.707	30.500	30.000	30.000	30.000

**(U) Mission Description:**

(U) Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. Thrusts are included in this project to improve our ability to navigate when the Global Positioning System (GPS) is jammed or otherwise unavailable; to increase the versatility of navigation systems applications by developing microelectromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation of short-dwell emitters or passive air defense systems.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
MEDUSA	10.773	13.005	15.000	15.000

(U) The Multifunction Electro-Optics for Defense of U.S. Aircraft (MEDUSA) program will develop the technologies and systems to give the U.S. air dominance at low altitude and at night. This program will develop the technologies to leap-frog reactive end-game countermeasures and enable increased threat warning times, denial of launch, and put Electro Optical-Infrared (EO-IR) air defense threats at risk. MEDUSA is a three-part technology program: (1) conduct phenomenological measurements and develop countermeasures and target classification/identification techniques; (2) develop critical component technologies such as high power IR laser sources, advanced IR detectors, and fibers for high power IR transmission; and (3) develop and demonstrate an end-to-end MEDUSA system. The MEDUSA technology is planned for transition to the Air Force and Army at the conclusion of technology development and flight demonstration, which is anticipated to be completed during FY 2011.

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E, Project GT-01	

- (U) Program Plans:
- Developed and evaluated MEDUSA countermeasure and classification techniques and conducted phenomenological measurements.
  - Fabricated and evaluated initial critical component technologies.
  - Continued refinement of MEDUSA system designs.
  - Built and demonstrated, from a tower, the breadboard MEDUSA design concept against realistic targets and environments.
  - Fabricate and evaluate full-scale focal plane arrays and supporting technologies to support flight domain objectives.
  - Build and flight test a MEDUSA brassboard design against realistic targets and environments.

	FY 2006	FY 2007	FY 2008	FY 2009
Advanced Gyroscopes	4.000	0.000	0.000	0.000

(U) The Advanced Gyroscopes program investigated the feasibility of a very high-accuracy gyroscopes and other technologies to provide extremely precise navigation, with a goal of reducing noise error to  $10^{-5}$  degree/hour or less. This would enable more robust operations in several applications—from underwater (including covert submarine operation and littoral navigation around obstacles) to outer space (from space flight to precise, autonomous satellite positioning). Technical challenges included the exploitation of quantum effects, such as correlated photons and atom interference effects, as well as gravity and gradiometer based technologies.

- (U) Program Plans:
- Developed concepts for achieving the required accuracy.

	FY 2006	FY 2007	FY 2008	FY 2009
Precision Inertial Navigation Systems	5.000	9.259	6.000	3.000

(U) The Precision Inertial Navigation Systems (PINS) program will develop an entirely new class of inertial navigation instruments using atomic inertial force sensors. These sensors utilize the quantum-mechanical wave-like nature of atoms in the atomic analogue of an optical

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Guidance Technology PE 0603768E, Project GT-01	

interferometer to provide unprecedented sensitivity to accelerations and rotations. The atomic sensors will further be used to measure the local gravitational field gradient to ensure that instrument alignment is properly maintained throughout vehicle maneuver, thus mitigating gravity-induced navigation errors. Initial program efforts will focus on developing fundamental technology components upon which future systems would be constructed. The PINS technology is planned for transition to the Navy and Air Force at the conclusion of Phase 3, which is anticipated to be completed by FY 2009.

(U) Program Plans:

- Develop and demonstrate an inertial navigation system with positional bias drift rate below 5 meters/hour.
- Develop compact narrow-linewidth, tunable 780 nm laser sources with large modulation bandwidth via monolithic solid-state microchip design.
- Demonstrate motion-compensated gravity gradiometer.
- Develop integrated hardware approaches for accurate navigation in densely built urban areas based on image matching.
- Develop and demonstrate technologies for undersea navigation commensurate with the needs of combat swimmers.

	FY 2006	FY 2007	FY 2008	FY 2009
Robust Surface and Sub-Surface Navigation (RSN/SSN)	11.500	15.700	12.000	5.000

(U) The Robust Surface and Sub-Surface Navigation (RSN/SSN) program will provide the U.S. Warfighter with the ability to navigate effectively when the Global Positioning System (GPS) is unavailable due to hostile action (e.g. jamming) or blockage by structures and foliage. The RSN/SSN program will use signals of opportunity and specialized signals from a variety of ground-, air-, and space-based sources and judiciously placed low frequency RF beacons; these will be received on the Warfighter's forthcoming software defined radios, and will use specially tailored algorithms to determine position. Other signals such as the Earth's magnetic field (micro deviations), cyclic variations in the Earth's gravitational field due to tidal motion, will also be evaluated. The greater strength and diversity of these signals will provide coverage when GPS is denied due to lack of penetration into buildings and underground, and when severe multipath is a problem. This is a two part program: (1) cataloging and assessing of potential exploitable signals followed by analysis and performance modeling and hardware-based concept validation and (2) designing, testing, and demonstrating of a (non-form-fit) prototype receiver(s) and algorithms for geolocation using the signals

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Guidance Technology PE 0603768E, Project GT-01	

of opportunity. The RSN/SSN technology is planned for transition to United States Special Operations Command, the U.S. Army and the U.S. Air Force by FY 2010.

(U) Program Plans:

- Evaluated feasibility of candidate approaches using modeling, analysis, and simulation.
- Developed critical RSN/SSN technologies and conducted phenomenological measurements to validate the down-selected concepts.
- Completed design and component-level testing of SSN system.
- Developed and conducted performance analysis of innovative algorithms for SSN that enhance form/fit of user receiver.
- Design, fabricate, and test functional prototype systems for above-ground and underground use.
- Field test and demonstrate the functional prototype in realistic environments.
- Perform technical risk mitigation experiments and analysis on the bimorph based magnetic sensors, the piezo-electric driving motors and signal and control processing algorithms.
- Integrate technologies into a micro sensor and radiometer structure.

	FY 2006	FY 2007	FY 2008	FY 2009
Navigation-Grade MEMS Inertial Measurement Unit (IMU)	9.500	15.500	11.000	5.000

(U) The Navigation-Grade MEMS Inertial Measurement (IMU) program will develop micro-scale accelerometers and gyros with navigation-grade performance that use only milli-watts of power. The program will transcend traditional single mass-spring methods for navigation sensing and will explore alternative approaches, such as multiple, interconnected mass-spring systems, micro-levitated spinning structures, micro-optical readout mechanisms, atomic interferometric readout mechanisms, and fluidic contortions. This program will transition by industrial performers by developing wearable inertial measurement units (IMUs) for dismounted warfighters capable of GPS-denied navigation for lengthy periods; small IMUs for unmanned air and underwater vehicles, and for guidance of small, long-range munitions—all of which will go into DoD systems.

(U) Program Plans:

- Attain 3D resonator structures (e.g., spheres, full wine-glass structures).

**UNCLASSIFIED**

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development		<b>R-1 ITEM NOMENCLATURE</b> Guidance Technology PE 0603768E, Project GT-01	

- Develop levitation methods.
- Develop fluid contortion sensing.
- Develop micro-environmental control.
- Control electronics integration.

	FY 2006	FY 2007	FY 2008	FY 2009
Active Electrol-Optical Mapping and Navigation System (AONS)	0.000	0.000	0.856	2.707

(U) The Active Electrol-Optical Mapping and Navigation System (AONS) program will provide GPS-denied navigation and detailed building interior mapping to soldiers operating in urban environments. AONS will employ electro-optic system strengths in image registration and precision range to track and map a soldier’s position continuously. Using image-flow methods, a compact, power-efficient camera and laser radar system will track the imagery from frame-to-frame and estimate camera pose and position information to provide the soldier a very precise determination of current position as well as a continuously updated map of the building or underground facility (UGF) being traversed. This same system will make real-time estimates of range and relative position of objects in the scene, and will provide real-time position estimates outside under GPS-denied conditions in urban, mountainous and foliated areas given access to a high-resolution terrain map of the area. This system would match small-scale features, such as shrubs, trees and small buildings, to features in the map and provide real-time estimates of the soldier’s location within that map. The capability will be transitioned to the U.S. Army via PEO Soldier and USSOCOM starting in FY 2010.

(U) The primary technical challenges are the development of compact, integrated high-resolution passive EO/IR and multi-pixel or scanning laser radar systems along with the development of real-time processing capability to provide the soldier up to date position estimates both inside building and outside buildings in GPS denied conditions.

(U) Program Plans:

- Develop initial real-time navigation algorithms based on real and synthetic data.
- Develop an integrated breadboard system with key initial sub-systems including video, laser radar and inertial navigation aids.
- Develop and demonstrate an integrated portable prototype AONS system.

**UNCLASSIFIED**

UNCLASSIFIED

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		<b>DATE</b> February 2007
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA3 Advanced Technology Development	<b>R-1 ITEM NOMENCLATURE</b> Guidance Technology PE 0603768E, Project GT-01	

- Demonstrate real-time navigation and building extraction.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

UNCLASSIFIED

R-1 Line Item No. 56

Page 8 of 8

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>							<b>DATE</b> February 2007	
<b>APPROPRIATION/BUDGET ACTIVITY</b> RDT&E, Defense-wide BA6 Management Support				<b>R-1 ITEM NOMENCLATURE</b> Management Headquarters (Research and Development PE 0605898E				
<b>COST (In Millions)</b>	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>	<b>FY 2010</b>	<b>FY 2011</b>	<b>FY 2012</b>	<b>FY 2013</b>
Total Program Element (PE) Cost	48.765	48.766	52.992	63.700	66.876	58.100	59.350	60.598
Management Headquarters (R&D) MH-01	48.765	48.766	52.992	63.700	66.876	58.100	59.350	60.598

**(U) Mission Description:**

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical security, travel, supplies and equipment, communications, printing and reproduction. During Base Realignment and Closure (BRAC) discussions, DARPA was instructed to work with the General Services Administration and Washington Headquarters Service personnel to prepare to vacate the Agency’s current headquarters building at the end of its lease (2010) and to take up residence in a building that meets force protection requirements. The FY 2008 and 2009 budget includes funds to begin design and trade studies and initial floorplan layout.

**(U) Program Accomplishments/Planned Programs:**

	<b>FY 2006</b>	<b>FY 2007</b>	<b>FY 2008</b>	<b>FY 2009</b>
Management Headquarters	48.765	48.766	52.992	63.700

**(U) Program Plans:**

- DARPA will continue to fund civilian direct-hires, both career and Section 1101 employees, and administrative support costs. Anticipated pay raise requirements are also funded. Full compensation for all 40 Section 1101 hires is reflected, including bonus packages.
- Security-related costs, to continue access controls, uniformed guards, and building security upgrades, are funded.
- CFO act compliance costs are funded, as well as DARPA’s pro-rata share towards the Defense Agency Initiative financial system.
- Design and Trade Studies in preparation for a move to a force-protection-compliant building are funded.

**UNCLASSIFIED**

R-1 Line Item No. 157

Page 1 of 2

**UNCLASSIFIED**

<b>RDT&amp;E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)</b>		DATE February 2007
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development (Research and Development) PE 0605898E	

– Layout Studies, Communication, and IT estimating and securing activities in preparation for a headquarters move are funded.

<b>(U)</b>	<b><u>Program Change Summary:</u></b> <i>(In Millions)</i>	<b><u>FY 2006</u></b>	<b><u>FY 2007</u></b>	<b><u>FY 2008</u></b>	<b><u>FY 2009</u></b>
	Previous President’s Budget	48.765	50.951	50.291	51.345
	Current Budget	48.765	48.766	52.992	63.700
	Total Adjustments	0.000	-2.185	2.701	12.355
	Congressional program reductions	0.000	-2.185		
	Congressional increases	0.000			
	Reprogrammings	0.000			
	SBIR/STTR transfer	0.000			

**(U)** **Change Summary Explanation:**

FY 2007	The decrease reflects a congressional program reduction and a decrease for Section 8106 Economic Assumptions.
FY 2008/2009	Increase reflects costs budgeted for building move expenses.

**(U)** **Other Program Funding Summary Cost:**

- Not Applicable.